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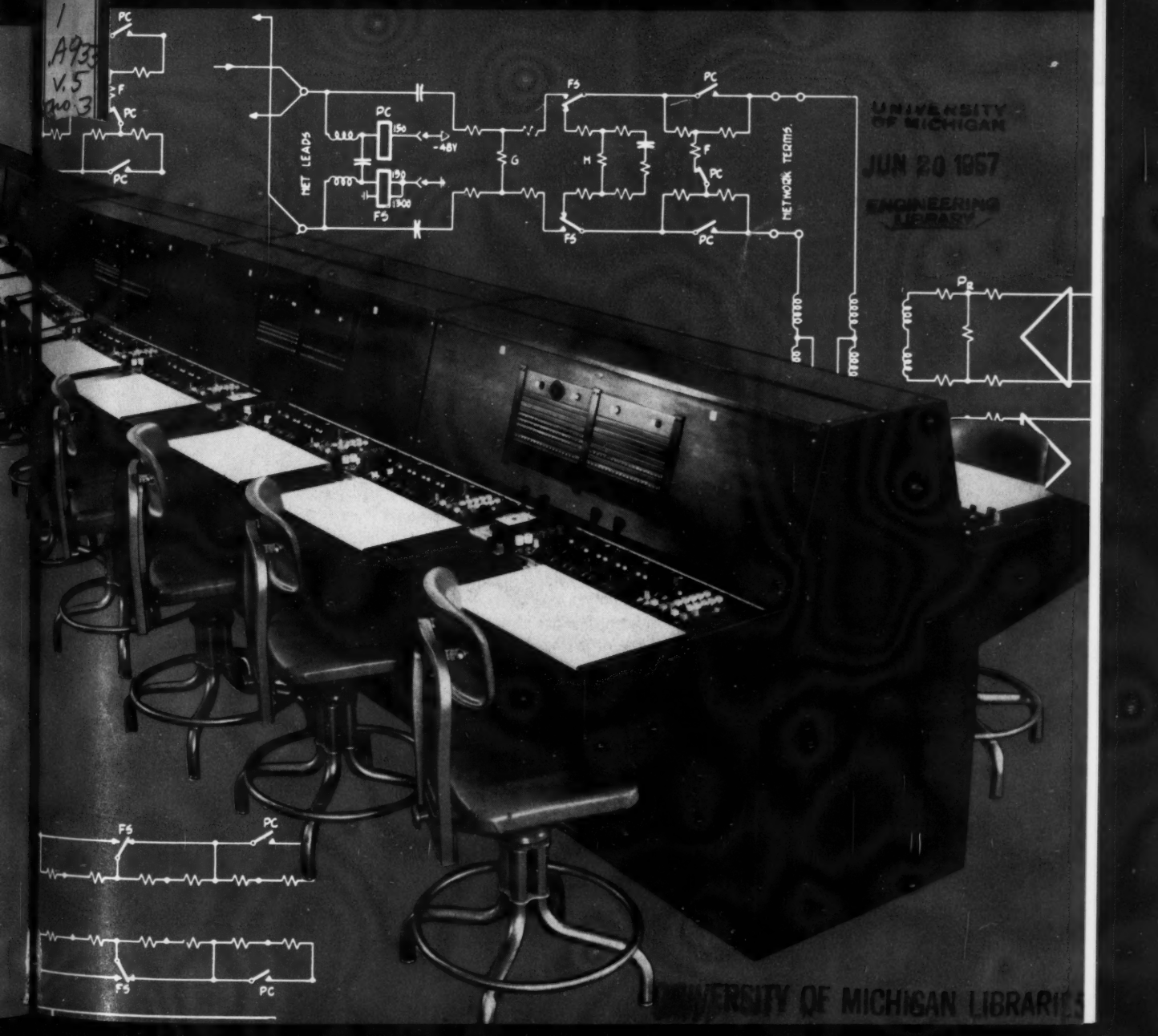

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GENERAL TELEPHONE

TECHNICAL JOURNAL

DEVOTED TO PROGRESS IN COMMUNICATION ENGINEERING

A Technical Publication of GENERAL TELEPHONE SYSTEM

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NOTE:

For many years Automatic Electric Company has issued the Automatic Electric Technical Journal. With the affiliation of Automatic Electric Company and General Telephone Corporation, System research and development is now centered in General Telephone Laboratories, Incorporated.

Since this publication endeavors to bring you the latest in communications engineering from all three phases of the industry—research, manufacturing, and operation—it is appropriate that the title of this publication has been changed from Automatic Electric Technical Journal to General Telephone Technical Journal.

You will continue to receive the Journal as usual, and we are confident that you will find it more interesting and helpful than ever before.

PREFACE

With this issue of the Technical Journal we bring you the final series of articles on the "FW-1" Intertoll Switching System. The first articles were presented in the December, 1956, issue.

We sincerely hope that the description of this step-by-step four-wire switching system—written by the engineers who developed this important contribution to toll operating techniques—has given you an understanding of this recent development.

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POSITION SENDER CONTROL AND SENDER

By R. T. EVANS
Staff Engineer, Telephone Switching Systems Development,
General Telephone Laboratories, Incorporated

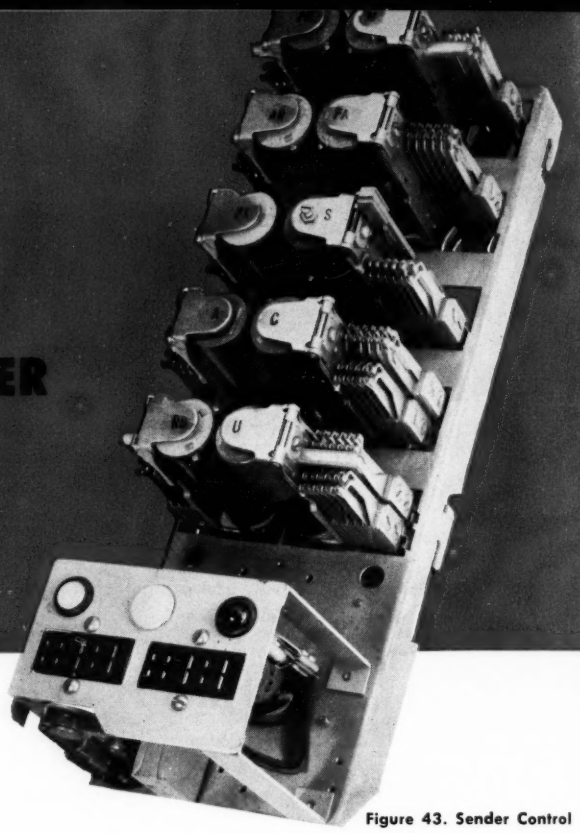

Figure 43. Sender Control

Cordless type operator positions are presently associated with the "FW-1" Intertoll Switching System. These positions are equipped with keysets which quickly convert digital information into coded form. This information is stored and then reconstituted in digital form and transmitted at the conventional dial pulsing speed of 10 pulses per second. The devices which control and perform these operations are the Position Sender Control and Sender.

Position Sender Control (See Figure 43)

The sender control circuit is a jack mounted unit consisting of ten relays and a 25 point rotary type sender-finder switch. (The switch is mounted separately.) This circuit contains those circuit elements which must be directly associated with each operator position to facilitate key sending. Two circuits are usually provided in order to provide overlap operation (simultaneous digit transmission over the rear and front of a link, or over two links.) The operator position circuit is arranged to use the sender controls alternately.

Sender Control Functions . . .

- Causes idle sender to be connected to the operator position.
- Serves as connecting link for all information and pulsing leads between sender and position, or sender and link.
- Receives *no further digit* (sender disconnect) signal from the keyset to prepare sender and sender control for release.
- Receives automatic ring information from the position and causes ringing to commence at proper time.
- Receives *end of sending* signal from sender and causes release of the sender and sender control.

When a call is distributed to a position, or when an operator pushes a dial rear key, a sender control is seized and caused to commence hunting for an idle sender. The sender finder rotary switch is arranged to be absence-of-ground-searching and is self interrupted. When an idle sender is found, the switch stops its rotation and a marginal relay is connected to the *test* lead of

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the sender. If this is an exclusive connection (not more than one sender control testing a particular sender at the same instant) a marginal relay operates, causing the sender to be seized; at the same time, this relay switches through various control and information leads.

If an exclusive connection is not made the marginal relay does not operate and the sender finder switch is caused to step off and hunt for another idle sender.

The idle status of the senders is continually monitored so that hunting by the sender finder switch can be prevented when all senders are busy.

During the time digits are being keyed into the sender the sender control acts only as a connecting link between the sender and the operator position. When the last digit has been stored a sender disconnect signal, which may or may not be accompanied by an automatic ringing

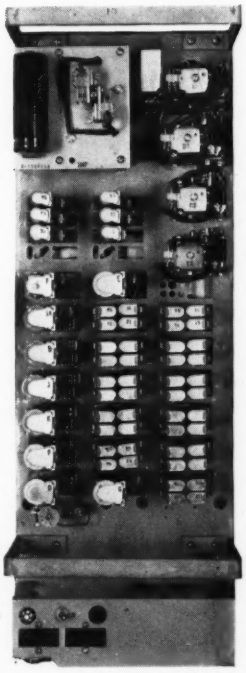

Figure 44. Sender

signal, is received from the operator position. The sender control is thus conditioned to release the sender upon completion of digit transmission, and to initiate automatic ringing if required. The sender control and sender are now able to complete their functions automatically, and the position may disassociate itself at this time, unless a dial rear call is in progress. In the latter case, the duplicate sender control may be seized and another sender placed in readiness to process a call over the front of the link. During digit transmission a termination is maintained across the line leads to provide transmission balance.

When the *end of sending* signal is received from the sender the sender control causes the sender to be released. In addition, the sender control places a ringing signal on the positive line lead for approximately two seconds, if automatic ringing is required.

The sender control is equipped with two ten-point test-jacks giving direct access to key points of the circuit. These jacks permit the use of a sender test set, and simplify maintenance. A busy key prevents the associated sender control from being seized and transfers its pick-up lead to the duplicate sender control. Peg count and rotary alarm are also provided.

Sender

The sender is a jack mounted unit containing those circuit elements necessary for key sending which may be shared by all sender controls (see Figure 44). Depending upon the number of senders required they may be placed in a single ungraded group, or within graded subgroups. ATB circuits are provided for both options.

The sender must be able to receive coded digital information rapidly for storage, and re-transmit this information at the conventional dial pulsing speed of 10 pulses per second. It must be able to detect stop dial and flash busy signals and cause appropriate action to be taken.

In order to accomplish these functions there must be a device which contains a storage medium, a sending device and some means of sorting and decoding information. As the coded information is received from the operator keyset it is sorted into individual digit storage groups by a storage sequence switch. There are eleven digit storage groups, each consisting of four min-

iature relays. When the information is to be read-out of the storage units, another sequence switch connects the storage units in turn to the bank of a decoding switch, the bank of this switch being marked by the storage units to correspond with the stored digit. For each impulse transmitted by the sender the decoding switch is advanced one step until the bank marking is found. At this time sending is stopped and a new marking placed upon the bank. This process repeats itself until all stored digits have been transmitted. The decoding switch is of the plug-in type.

The interdigital time is controlled by counting a number of impulses generated by the impulsing device. This is accomplished by marking the bank of the decoding switch during the interdigital period. This timing may be readily changed by altering the code placed on the bank of the code switch.

The actual impulsing device consists of cam driven impulse springs operated by a 24-volt A.C. synchronous motor. This prime mover was selected in preference to somewhat less expensive relay impulsing devices because the speed and percent make of the pulsing contacts can be expected to remain constant throughout the life of the equipment without adjustment. It also represents a considerable reduction in components when compared with other sending devices with similar features.

When seized, the sender pilot lamp associated with the operator position is lighted indicating the sender is ready to receive digits. In addition, another lamp associated with the link to which the sender is connected, is flashed. Digital information is received in *w, x, y, z* code over four leads from the keyset. Each time that a digit key is depressed the appropriate digit storage relays are operated and locked; when the key is released the storage sequence switch is advanced to the next digit storage relay group. Digits may be stored until all eleven storage units are used.

The *read-out s*equence switch has the function of connecting the digit storage relay groups to the bank of the decoding switch. As soon as the first digit is stored and the storage sequence switch advanced, the first digit may be re-transmitted by the sender. When the first three digits have been re-transmitted the associated digit storage relay groups are released. They may then be reused to increase the digit storage capacity of the sender to fourteen digits.

Provision is also made so that the *read-out* sequence switch cannot override the "storage" sequence switch. Thus, the decoding switch cannot be connected to a digit storage relay group which has not received information.

During impulsing the sender must be able to recognize stop dial or flash busy signals and take appropriate action. A stop dial signal consists of a single off-hook condition transmitted toward the calling end of the connection for the duration of the stop dial condition. A flash busy consists of repeated off-hook, on-hook signals transmitted toward the calling end. Reception of an off-hook signal by the sender causes temporary suspension of further digit output, and the initiation of a 3 second timing interval. During this interval the off-hook signal may revert to an on-hook, without further consequence. However, a second off-hook signal indicates a flash busy signal and the sender immediately signals the sender control that no further digits are to be transmitted. The sender control then initiates the release of the sender, and flash and tone busy are returned to the calling party directly from the point at which the busy condition was encountered. A posted circuit condition causes the sender to be released in the same manner as a busy condition.

If the signal received was a stop dial, sending is suspended until an on-hook signal is received with the provision that the timing interval must be completed. A prolonged stop dial condition causes the sender pilot lamp (associated with the operator position) to be flashed at 120 IPM.

Certain operator positions are arranged to receive preference in seizing trunks in posted groups. Since posted trunk groups are not available to ordinary traffic a special condition must exist to gain access to these groups. The operators who are to have access to these groups push a *"cut-in"* key prior to dialing any digits. This causes a relay to be operated and locked in the sender placing a 600-ohm ground signal on the positive line lead during transmission of the first three digits. This signal serves to condition the appropriate selectors so that they may hunt for trunks in the posted groups.

The sender base is equipped with a test-jack bracket containing two ten point test-jacks. These test-jacks permit the sender test set to be used in addition to giving access to the important points of the circuit. The bracket mounts a toggle switch which may be operated to clear impulsing contacts of all attachments so that accurate pulse measurements may be made.

Adequate provision has been made for conducting detailed traffic studies of sender operations. Trafficorder measurements may be made of total sender traffic, digit storage time, and digit transmission time. Peg counts indicate sender usage and total digits processed.

MISCELLANEOUS TRUNK CIRCUITS

By R. T. EVANS

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Combined Line and Recording Trunks

Combined Line and Recording Trunks (CLR) may be divided into four general classifications depending upon their mode of access and according to the class of station that they are to serve. They are: three-wire coin type trunks, three-wire non-coin trunks, two-wire coin trunks and two-wire non-coin trunks. Application of either coin or non-coin types of trunks is obvious. The decision as to whether two-wire or three-wire trunks are to be used is an economic one depending upon the relative cost of provid-

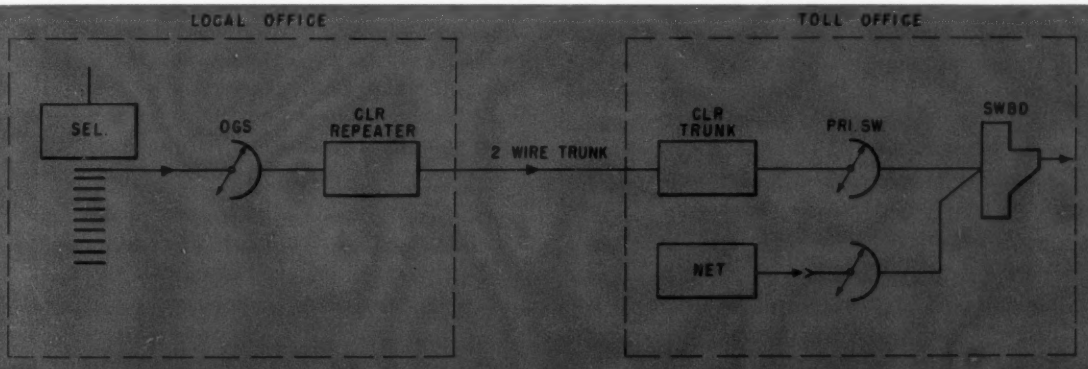


Figure 45. Application of CLR Repeaters When Two-Wire Interoffice Trunks are used

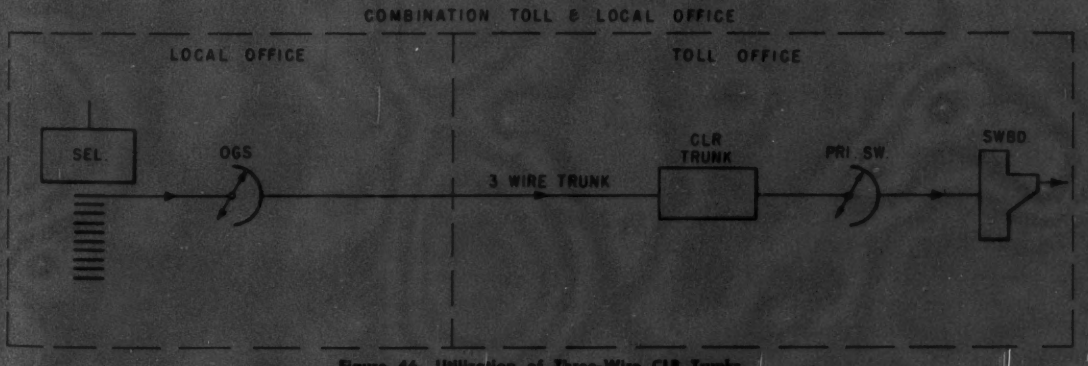


Figure 46. Utilization of Three-Wire CLR Trunks

ing three-wire circuits between the local office and the toll office, or providing two-wire circuits between the two offices in addition to a CLR repeater which must be furnished at the local end (see Figures 45 and 46).

Many features of CLR trunks are common to all four varieties. When seized, control leads are closed to the incoming primary and secondary call distribution circuit. If links are available, a start signal is received from the distribution circuit, and a rotary switch associated with the CLR trunk starts to hunt for an idle link. Ringback tone is returned to the calling party while waiting for an idle link. The switches are battery searching and relay interrupted. When an idle link is found the transmission and control leads are switched through to the link. Release of the CLR trunk (and the calling switch train) is under control of the toll operator. During the hunting operation of the line-switch, a delayed office alarm lead is closed which causes an alarm to be given if a link is not found within a reasonable length of time.

Each trunk is equipped with checking facilities so that the toll operator may identify the trunk by operating the position check key. Traffic leads are provided for Trafficorder measurements of the total holding traffic and waiting traffic (time required for an idle link to be found). In addition to a peg count lead, complete facilities are provided for service observation and control console monitoring.

When an operator answers a call from a three wire coin type CLR trunk, refund battery is momentarily closed to the incoming line to return any coins which were deposited in order to reach the toll board. In addition to a special identity lamp lighted at the operator position, a special tone is transmitted to the operator for a short time to further identify this as a paystation call. Toll grade transmission battery is furnished to the calling party. Re-ring features are provided on all coin type trunks.

All of the features provided with three-wire trunks must be furnished when two-wire trunks are used. In order to accomplish these functions it is necessary to provide CLR repeaters at the local office end of the interoffice trunk. These repeaters return ringback tone to the calling party, provide coin control repeating functions (including the initial automatic refund pulse) provide toll grade transmission battery, and also provide for CLR holding of the local switch train. All other functions are provided by the two-wire trunks in the toll office.

Three-wire and two-wire non-coin type CLR trunks function similarly to the coin type trunks described above, with the exception that no coin, associated special tones, lamp signals or re-ring features are required. Ten joint test-jacks are provided to enable the trunk test set to be used. The circuits are jack mounted for ease of maintenance.

It is at times desirable to provide two-wire CLR trunks with a compromise or precision network to balance the impedance of the interoffice trunk. This is only necessary where the transmission level needs to be improved and terminal repeaters are not provided in the two-wire circuit. The increased balance provided by the network increases the return loss of the hybrid terminating the four-wire circuit and enables the circuit to be operated at a lower loss. When this network balancing circuit is required, it is provided at the CLR trunk and connected to the hybrid through the switching office by means of the net leads[1] (see Figure 45).

Toll Switching Trunks

Toll Switching Trunks are the "outgoing" equivalent of the two-wire CLR circuit. Only two conductors are needed to connect them to the toll train in the local office (see Figure 47). They are used when it becomes too expensive to provide the extra conductors required between the toll and local office when a toll transmission unit is provided in the toll office. In addition to the switching trunk, an incoming toll transmission relay group or toll transmission selector is also required at the local office.

Toll Switching Trunks, like the CLR trunks, may be divided into several categories. They may be of the coin or non-coin type and may or may not have digit absorbing facilities as the case may be. The coin control features are less complicated than in the CLR trunks, since the coin potential is always passed through the circuit—not repeated, and an automatic refund

[1]Refer to Figure 10, Page 65, December, 1956, Automatic Electric Technical Journal.

pulse is not required. Toll grade transmission is not furnished by the switching trunk, but rather by the transmission selector or relay group in the local office. Repeating coils are provided to match toll and local plant impedances.

The toll switching trunks are seized from the banks of the intertoll selectors. Upon seizure, a loop circuit is closed to a toll transmission selector, or relay group in a local office. If digits are to be absorbed, the circuits can be arranged to absorb the first one or two digits to be dialed through the trunk. Subsequent digits, when dialed, are converted from EC lead pulsing into loop pulses. At the completion of each dialed digit incoming from an intertoll trunk, a ringing signal is placed on the positive incoming line lead which serves to cock an automatic ringing start circuit. When the called line is seized by the connector, the polarity of the loop from the local office is reversed. The switching trunk then sends a short burst of ringing current to the local office, causing automatic ringing to be started by the connector. If the call is coming from the toll board a ringing signal is received either automatically or manually after all digits have been dialed. The same cocking mechanism is operated and a local loop polarity reversal causes ringing of the called station to commence. When called party answers, a dry line loop causes supervision to be returned toward the calling end.

From the time that the switching trunk is seized until the called line is seized, the incoming line leads are bridged with a termination. After the called party has disconnected, re-ring may be accomplished by a momentary ringing signal being sent forward from the calling end of the connection.

In the idle state, a small current over the loop to the local office holds a switching trunk relay operated. If the transmission relay circuit or selector is removed or busied out, or if there should be discontinuity in the interoffice trunk, the switching trunk will be made busy by the restoration of this relay.

Like the two-wire CLR trunk, it might be desirable to improve the transmission level by the inclusion of compromise or precision networks which balance the interoffice trunk. When this is required, the net leads from the incoming four-wire trunk circuit are connected to the network at the switching trunk.[1] All toll switching trunk circuits are provided with peg count facilities as well as leads to the checking circuits. Traffic leads provide for use of a Trafficorder. Jack mounting facilitates maintenance.

Toll Transmission Trunk Circuits

Toll transmission trunk circuits combine the features of the toll switching trunk in the toll office, and the incoming toll transmission relay group in a local office. The output from the trunk circuit is connected directly to a toll intermediate selector located in the local office (see Figure 48). This necessitates the use of four

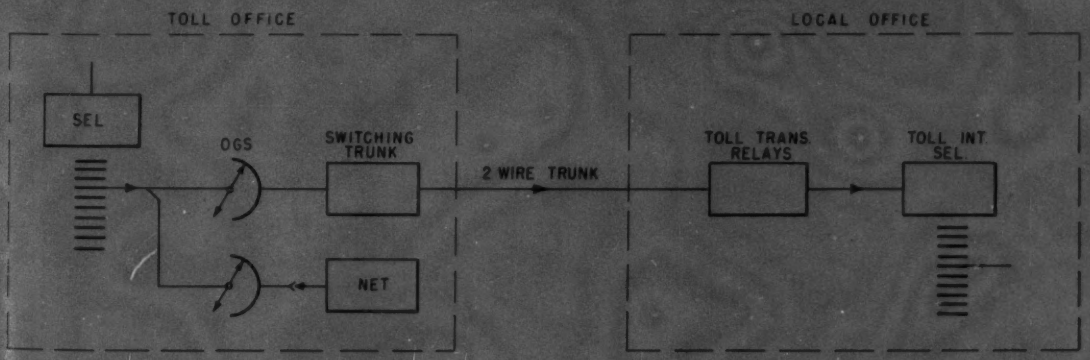


Figure 47. Use of Toll Switching Trunks where Two-Wire Circuits must be used between Toll and Local Office

wires and it is this feature which limits the use of these circuits to those locations where the toll office and local office are close to each other. A busy back feature is provided so that the trunk circuit is made busy on the banks of the intertoll selectors when the associated toll intermediate selector is removed from service. The circuits are jack mounted for ease of maintenance. Leads are provided to the checking circuit as well as for traffic measuring purposes.

Outgoing Trunk to Local Switch Train

These simple outgoing trunk circuits convert EC lead pulsing from the intertoll switches to loop pulsing as required by the local switches. Either two or three conductors may be used to connect them with the local office. Checking features are provided, but coin control, controlled ringing, digit absorption, etc., are not furnished. A busy back feature is provided if three-wire interoffice trunks are provided to the local office. The circuits are jack mounted.

Common Battery Trunks

Common battery trunks are provided to enable a subscriber's station to be reached directly from the banks of the intertoll selectors, and to enable the station to gain direct access to the toll board by means of a lineswitch (Figure 49).

These trunks combine many of the features of CLR and transmission trunks, including ringback tone, toll grade transmission battery feed, re-ring and checking features. Coin control is not provided; service observation, control console, peg count, rotary alarm and traffic measuring leads are provided.

On calls to a C.B. line, automatic ringing is started when a ringing signal is received from an intertoll trunk, or the toll board. Ring-trip is provided when the station is answered.

Reverse battery supervision is returned to the C.B. line when the operator answers on calls to the toll board. In addition, a special identity lamp signal may be provided for the operator to identify this class of service. The C.B. trunks contain a ten point test jack which provides access for the trunk test set. The circuits are jack mounted for ease of maintenance.

Verification Trunk

The verification trunk is a five relay jack mounted circuit used in verifying line numbers from which subscribers place toll calls. The trunk may be seized from the intertoll selector banks; it requires two line leads in addition to the C and EC leads. A special verification switch is connected to the output of the trunk, which requires two leads for loop pulsing purposes,

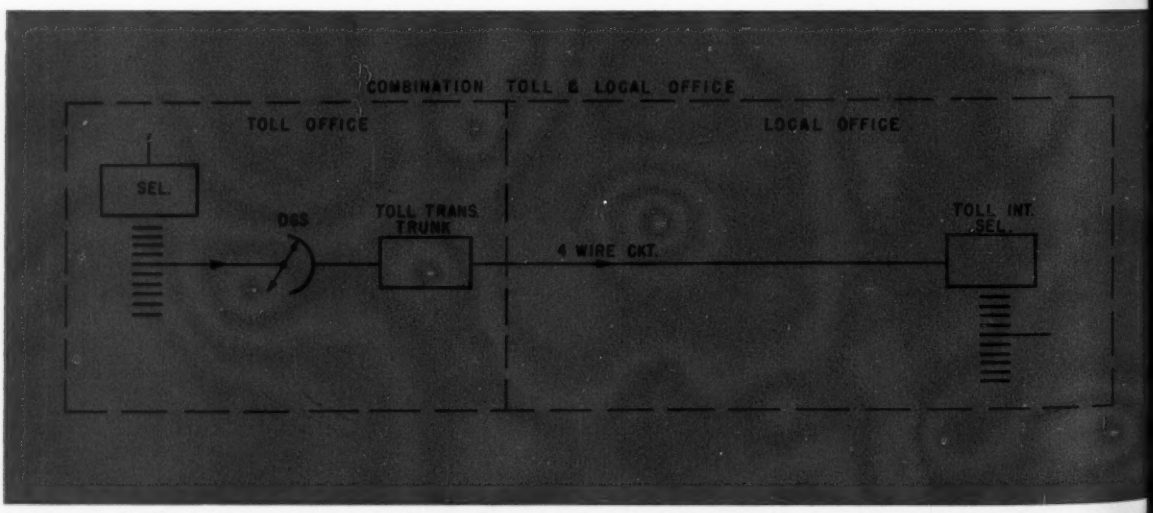


Figure 48. Use of Toll Transmission Trunk when Toll and Local Office are close enough to permit use of Four Conductor Trunks

and two leads for tone transmission purposes.

When the trunk is seized, the loop to the verification switch is closed in readiness for impulsing. Impulses received over the EC lead from the intertoll switch banks are converted into loop pulses which step the verification switch to the calling line terminals. When the calling line is reached, reverse battery is returned, causing the toll operator's supervisory lamp to darken. At this time the operator may operate the position ringing key which causes a special tone to be placed on the calling line through the verification switch. The toll operator is thus able to verify the validity of the calling party's number, since the verification tone will be audible to the operator over the rear of the link.

The verification trunk is provided with a traffic measuring lead suitable for use with a Traffic order. A peg count lead and an ATB lead are also provided.

Plug Ended CLR Trunks

Two plug ended CLR trunks (coin and non-coin type) have been designed for use at manual offices in order to gain access to the toll board. These trunks are the manual office equivalent of the CLR repeater circuits provided at automatic offices when two-wire interoffice trunks to the toll board are used. Two wire coin or non-coin CLR trunks are provided at the toll board end of the interoffice trunks.

These circuits furnish toll grade transmission battery to the calling party and provide disconnect supervision to the manual operator when both the toll operator and calling party have disconnected. In addition, the coin type trunks cause coin signals from the toll board to be repeated to the calling line.

A tip busy test is provided on both trunks.

Supervisory Test Line

A supervisory test line trunk is provided which enables any distant operator to verify proper operation of the lamp supervisory signals. Upon seizure of this trunk, off-hook supervision is returned. If a ringing pulse is sent into the trunk, the signal is changed to an on-hook condition. When another ringing pulse is sent into the trunk, the signal changes to 120 IPM flash busy and the test is completed. During the test the line leads are terminated.

Transmission Test Line

A transmission test line trunk is furnished which provides a 1000 cycle, one milliwatt test tone. Upon seizure of this trunk, off-hook supervision and tone is returned. After several seconds have elapsed, the tone is disconnected and on-hook supervision is returned.

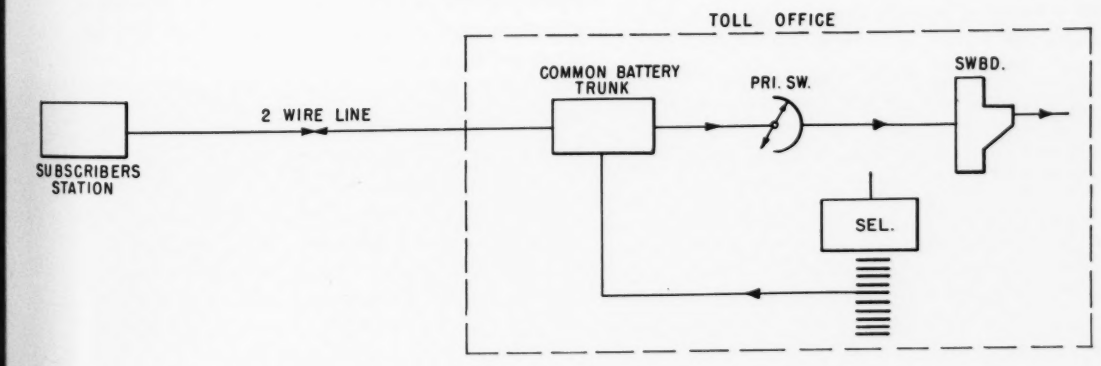
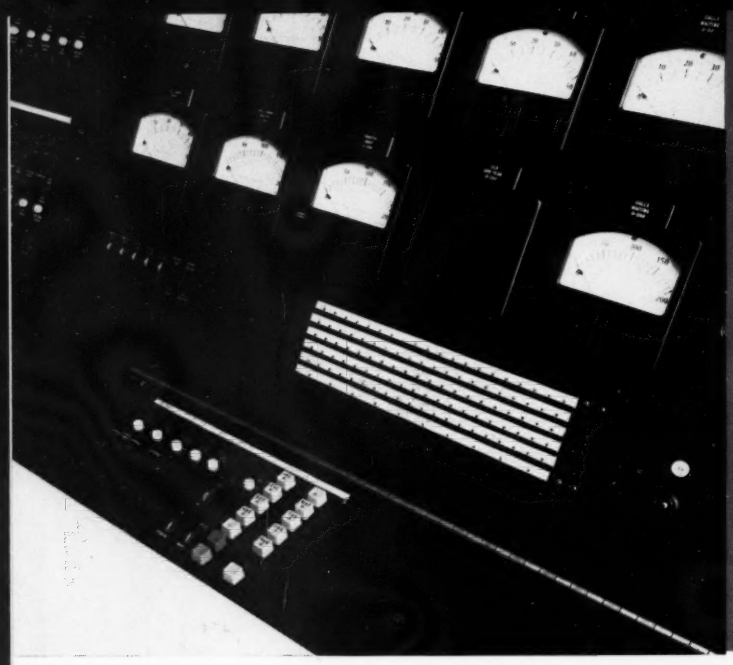


Figure 49. Arrangement of Common Battery Trunk Circuit which Provides Direct Subscriber Access to Toll Board



THE CONTROL CONSOLE

By E. J. GLENNER
Project Engineer, Telephone Switching Systems Development,
General Telephone Laboratories, Incorporated

Figure 50. Supervisor's Control Console

Previous articles in the Technical Journal introduced several new concepts pertaining to the design of the "FW-1" Intertoll Switching System. In such a vast switching system—with its complete intertoll dialing and alternate routing facilities using a high speed automatic cordless toll board with a new method of distributing calls, the control console is an essential piece of equipment for the control and supervision of traffic operation. It is the "nerve center" of the system since it is the one centralized point where supervisory information is obtained.

For practical and administrative purposes, the control console is usually associated with a toll operating unit having a maximum of 48 operator positions. In larger installations consisting of several operating units, a "unit control console" is provided for each toll operating group. Each unit console supervisor can direct those functions required for the administration of each associated toll operating unit. In addition, a "master control console" may be provided as a centralized supervisory point for the complete operating system. The master console has control of the functions affecting all units and, in addition, those functions which enable the master control console supervisor to co-ordinate the activities of the unit console supervisors.

Each control console contains positional equipment and various types of trunk circuits used for setting up connections to local or intertoll equipment, or between desks. The positional equipment, although similar to a toll operator position, is simplified. This is reasonable since the supervisor in charge of a control console does not have the same functions as a toll operator. Only infrequently is it required to set up connections from the console to other points or to receive incoming calls from toll positions. A large portion of the control supervisor's functions is administration. Visual indications pertaining to traffic and supervisory conditions within the toll operating unit are received by the console supervisor, who acts upon this information in various ways. This will be discussed later in this article.

Meter Reading Indications

So that the control console can be an effective supervisory point, information and supervisory signals must be presented in a straight-forward, easy-to-understand manner. To accomplish this, it is equipped with panel mounted ammeters which indicate information such as traffic busy, number of calls waiting, and TX traffic busy (see Figure 50).

The circuit used to present this information is illustrated in Figure 51. When a CLR trunk is seized ("0" level call) and the call is waiting for an operator, a 10,000-ohm resistor is ground-

ed in the trunk circuit and connected to the call waiting meter This allows a current of approximately 5 ma. to flow through the ammeter circuit (calibrated to read "1" corresponding to a current of 5 ma.). If more calls are waiting, additional 10,000-ohm resistors will be connected to the circuit, each additional resistor giving a 5 ma. increment to the meter reading.

In some installations, for accuracy, two meters are provided in series, one a low reading meter (0-50), and the other a high reading meter (0-500). A meter switching relay is provided to switch the low reading meter out of the circuit when its limit has been reached; at this point only the higher reading meter remains in the circuit (see Figure 51). The meter switching relay again introduces the low reading meter when the current has dropped sufficiently to be within its range. Each meter circuit is arranged to prevent the meter switching relay from operating and restoring by instantaneous increments or drops in current when the nominal current is at the full scale reading of the low meter. This prevents the needle on the low reading meter from fluctuating back and forth on momentary traffic variations.

All other meter reading circuits on the control console are operated identically to the above circuit description. The following meters used on the control console provide information regarding their associated toll operating units:

The *traffic busy* meter gives a reading of the total number of busy incoming trunks that form a part of the incoming call distribution. This reading is comprised of those trunks that are seized (busy) but awaiting operator answer, in addition to those busy trunks already answered.

A *call waiting* meter indicates the total number of trunks (as a part of the incoming call distribution) that are seized and still waiting for an operator to answer.

Operator team meters give an indication of the number of operator positions that are staffed in this unit. Operator team meters are provided for each class of service having a separate incoming call distribution. Thus, when a regular operator position is staffed, the meter increases its reading by "1". On a special delay position capable of handling both regular and special delay traffic, when the operator is present and made available to both types of traffic, an operator team meter for each class of service reads "1" additional operator present. If the special delay operator position is busied to regular traffic by operation of its CLR cut-off key, then only the special delay operator team meter will indicate this operator present. Conversely, operation of the TX cut-out key busies the position to special delay traffic and consequently, only the regular operator team meter will indicate this operator.

An *all links busy* meter gives a reading of the number of operators that are present and have all of their links busy. In this case, a link is considered busy only if it is handling an active call and not if the operator is merely denying incoming traffic to links made busy to incoming calls (as an example, by operation of the answer disconnect key).

A *toll trunk traffic busy* meter gives a reading

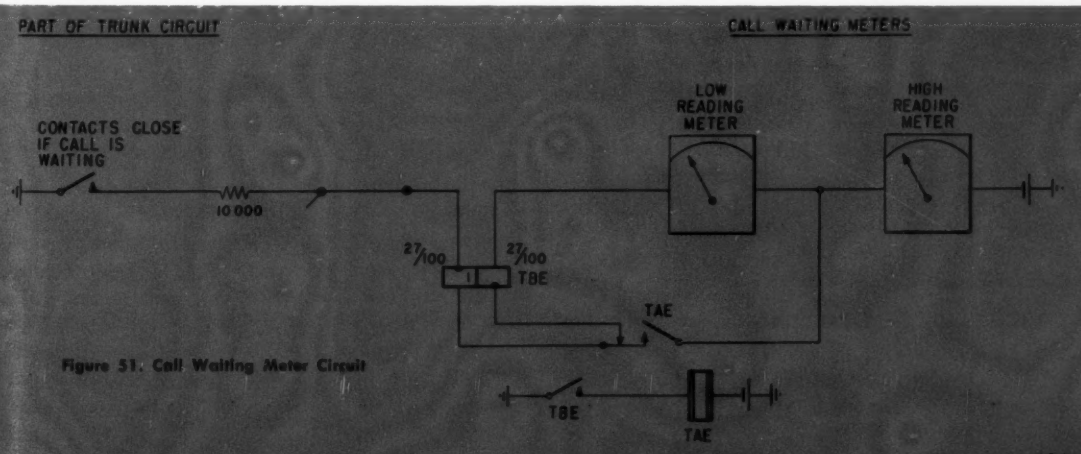


Figure 51. Call Waiting Meter Circuit

of the total number of toll trunk circuits that are busy at any one instant. This meter gives an indication of the bulk toll traffic and totalizes all of the busy toll trunk circuit groups on one meter. However, each toll circuit group has an associated group busy check push key which, when operated, removes that particular toll circuit group from the toll trunk traffic busy meter and connects it to a common *check meter;* the number of busy toll trunk circuits in only the one group is then indicated on this meter. This, then, reduces the number of meters required, since each individual toll trunk group does not need its own meter, but uses the common check meter which may be associated with any one trunk group.

Also, every time a toll circuit is placed on OD (out of order) a 10,000-ohm ground circuit is placed on an OD check key associated with any one toll circuit group. The reading on the busy check meter gives an indication of how many circuits are out of order.

The control console check meter has other functions. If a separate all links busy meter (as described above) is not provided, this indication may be given by operation of an all links busy push key which connects the proper 10,000-ohm resistors to the check meter circuit.

In a similar fashion, an operator team check key, TX operator team key and operator trunk group busy check key may be associated with the check meter (by key operation) and not require a separate meter for each indication.

On the control console each toll circuit group in the system has a toll circuit group control unit consisting of an OD check and group busy check key as described above, and an OD lamp and group check lamp. In addition, there is an overflow and posted delay lamp, and a hand operated selector switch for placing the toll group on reorder, camping, or posted delay. This operation is explained in Camp-On-Busy Selector (Journal, December, 1956).

Call Waiting Signal Circuit

A call waiting signal circuit is provided for each class of service having a separate incoming call distribution. The circuit weighs the number of calls waiting versus number of operators present, to provide supervisory signals to the supervisor in charge of the control console.

The ratio of positions staffed (and handling incoming calls in this distribution), to the maximum number of calls waiting which still gives a good grade of service, is not a fixed one but is computed from a mathematical formula. For example, if with four operator positions staffed there were as many as five calls waiting, this would not be considered too many. If seven or eight calls are waiting with only four positions available, the unit may become congested. On the other hand, with as many as 40 positions available there can be as many as 28 calls waiting, and under normal conditions, they can be handled without congestion. However, if 30 or more calls are waiting, with 40 operator positions staffed, congestion may exist.

Elements of the call waiting signal circuit are shown in Figure 52. Each position circuit that is staffed and available has a 10,000-ohm ground connected resistor connected to the PMR lead of this circuit. Similarly, each trunk circuit that has been seized and awaiting connection to an operator has a 10,000-ohm grounded resistor connected to the WLR lead. Approximately every 10 minutes the ST relay operates for a few seconds, homing the CW switch which operates relay CC. After the rotary switch is at home position, ST releases and closes the circuit to polarized relay W and its Wheatstone bridge circuit.

If we assume that there are ten positions available, there will be ten 10,000-ohm resistors in multiple from the position circuits at point PMR. Thus, a 1,000-ohm ground is connected to the No. 1 terminal of relay W, in addition to a resistance battery through wiper level A of rotary switch CW. Now, the RA-1 resistor value is 10,000-ohms; thus on the first rotary switch position, the No. 1 terminal of W will be positive with respect to the No. 4 terminal (which is at approximately −24 volts). Relay W, being a very sensitive polarized relay, operates when its No. 1 terminal is positive with respect to its No. 4 terminal, thereby closing the circuit to WR which in turn steps rotary switch CW. This switch steps relay-interruptedly until the resistance scanned at level A is of low enough value to balance the Wheatstone bridge and prevent relay W from operating.

On step 8 of the rotary switch, battery connected resistor RA-8 is 870-ohms. Terminal 1 of W relay will be negative with respect to terminal 4, and relay W will not operate. During the stepping of switch CW, relay CC, being slow to release, remained operated. When the switch finally stopped on step 8, relay CC released. This rotary switch (CW) step corresponds to ten operator positions available. We must now determine the number of trunk circuits waiting for service.

The battery connected (RB) resistor corresponding to the eighth step is RB-8 with a value of 1200-ohms. If no calls are waiting, the WLR terminal is open. Therefore, polarized relay W will not operate since its No. 1 terminal is negative with respect to its No. 4 terminal. If eight calls are waiting, for example, there will be eight 10,000-ohm ground connected resistors at point WLR (a combined resistance of 1250-ohms). Since RB-8 is only 1200-ohms and connected to battery, relay W will still not operate. Now, if the number of calls waiting increases to 10 or more, terminal 1 of relay W will become positive with respect to terminal 4 and relay W will operate. This closes the circuit to WR and lights the calls waiting lamp at the control console, indicating a condition of congestion to the control supervisor.

In addition, the pilot lamp control grouping relay (not shown) will operate to light the call waiting lamps throughout the toll board so that the operators will get an indication that an excess number of calls are waiting. If the congestion is alleviated and the number of calls waiting drops, relay W will restore and the calls waiting lamps will be extinguished. On the other hand, if the congestion remains for approximately one minute, a slow acting bi-metal relay will operate, flashing the calls waiting lamps. The supervisor in charge of the control console, and also all toll operators in the toll operating unit, will know that the congestion is becoming more acute and action should be taken to alleviate this. As an example, the control supervisor may instruct certain operators to return their positions to normal CLR operation if they had their CLR cut-off keys operated and were, therefore, denying this type of incoming traffic to their positions.

Miscellaneous Indications

The supervisor in charge of the control console also has emergency start keys which may be

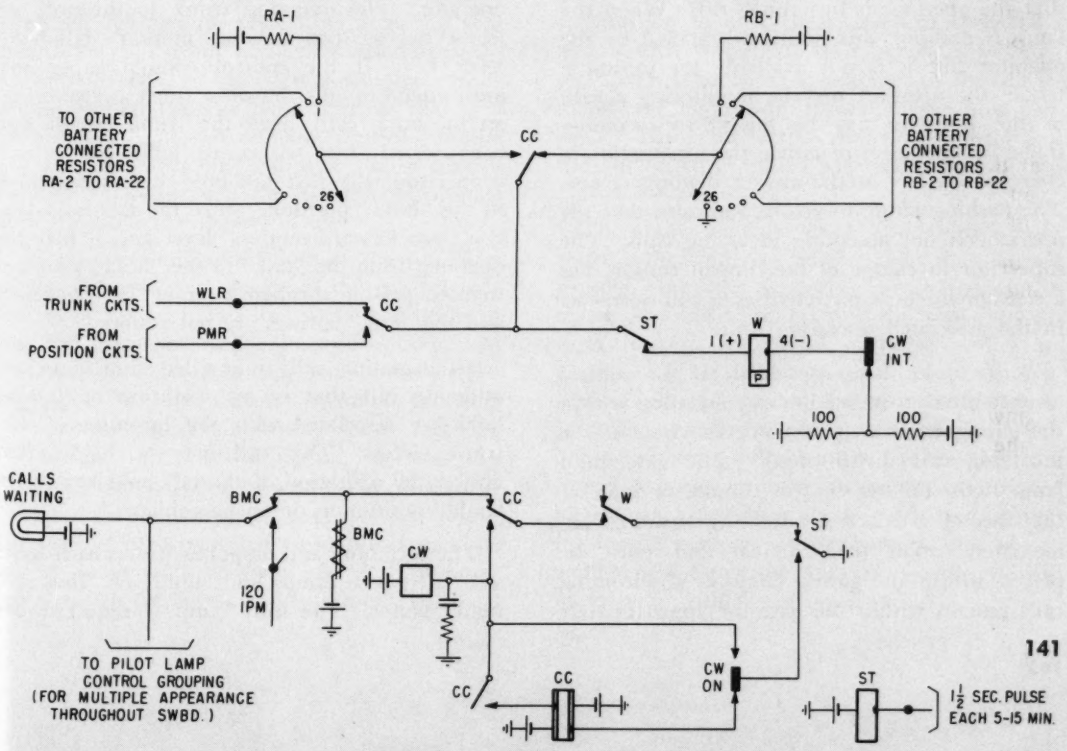


Figure 52. Call Waiting Signal Circuit

used to permit all waiting calls to hunt for idle operator links on a no-preference basis. TX trunk night transfer keys are also located at the control console, and their operation will transfer the TX trunk from one group to an appearance on another group (in other words, the trunks will be grouped together on one common TX station). A TX trunk busy circuit is provided per TX group to give the control supervisor an indication that all TX trunks are busy (or all operator trunks, as the case may be). In addition, TX and CLR cut-out lamps are provided for each position of a TX station. A lighted TX cut-out lamp indicates that the operator position has operated the TX cut-out key, thereby busying the position to TX (special delay traffic). Conversely, operation of the CLR cut-out key lights the corresponding lamp and indicates that the position is denying incoming CLR traffic.

Position supervision of the toll positions is presented at the control console by means of a lamp control circuit and pilot check keys. By operation of a pilot check key, a maximum of 20 positions have their pilot lamps connected to the control supervisor. Broadly speaking, when the pilot lamp lights the operator position is available for service and is waiting for an incoming call. An extinguished lamp indicates that the operator is busy on a call. When the lamp is flashing, this position is staffed by the operator but it is not available for incoming traffic; the operator may be monitoring a call, or the position may be busied to incoming traffic by operation of either the automatic answer cut-out key or the answer disconnect key. The flashing lamp, therefore, indicates that the operator is not accepting incoming calls. The supervisor in charge of the control console has a convenient check on activities of toll operators in the associated operating unit.

A gate pilot lamp provided on the control console gives an indication of congestion within the gating circuits (preference function of the incoming call distribution). The gate pilot lamp lights on the control console to indicate that incoming calls are not being answered immediately upon their arrival and must be placed within the gating circuits. If incoming calls remain within the gate for approximately 30 seconds, the lamp will flash at a 120 IPM rate as a visual indication.

Positional Equipment and Trunk Circuits

The control console supervisor has very little need for communicating with other desks, but a position circuit and trunk circuits are provided so that when the need arises, all functions can be performed. The supervisor position equipment consists of a key set for setting up calls (keysenders used instead of dials), a sender seize key, error key, sender disconnect and cut-in key, (the latter four being part of the key set) and talk-monitor, coin collect, coin return, ring and check lever keys. The positional ring, check, coin, error, cut-in and sender disconnect keys have the same standard functions as the similar keys on the toll positions. In addition, the trunk circuits will have either talk keys or talk-hold (two forward motion) keys—one for each circuit.

An outgoing call may be set up from the control console by operation of the talk key of one of the outgoing trunk circuits to intertoll selector. A sender is seized by operation of the sender seize key, with the connection being established by keying in digits to set up the switch train in the same fashion as by a toll operator. The outgoing trunk to intertoll selector has a "two forward motion" talk-hold lever key. If the control console supervisor must attend to other business (such as answering an incoming call) after the trunk circuit has been seized, but wishes to hold the initial connection, the first talk-hold key is operated to the "hold" position. Since the talk-hold key is a "two forward motion" lever key, it may be operated from the "talk" to the "hold" position without passing through a center "off" position and the "talk" springs are not restored.

An incoming call is handled similar to an outgoing call—that is, by operation of a talk-hold key associated with the incoming (call) trunk circuit. This call may be held, after answer, by operation of the talk-hold key to its "hold" position as on an outgoing call.

The incoming and outgoing trunks each have associated busy lamps and "hold" or "line and hold" lamps. The busy lamp is required be-

cause several trunk circuits may be associated with more than one control console or desk, and when an outgoing trunk is seized by a supervisor in charge of one control console, the busy indication must be given to others to prevent intrusion by them. The incoming trunk from intertoll selectors has an audible auxiliary signal (under the supervisor's control) used to signal at night and recall the control supervisor to a temporarily vacated desk.

A two-way call circuit between desks may be provided. Operation of the associated talk key will seize the circuit and signal the called desk. Answer and disconnect supervision are given, and provision is made for an auxiliary signal as a night alarm.

Provision is made for a two-way trunk circuit to local equipment. This circuit is a local telephone line. Operation of a talk key seizes the circuit for an outgoing call as on a call originated by a local subscriber. The circuit may be temporarily held by operation of the associated hold key while the supervisor in charge of the control console momentarily attends to some other activity (such as answering an incoming call). An additional provision is made on this circuit for answering or originating local calls by a desk telephone set.

All of the trunk circuits are arranged with guarding facilities for preventing a control console supervisor from accidently attempting to connect to two trunk circuits simultaneously. Outgoing and two-way trunk circuits that may be accessed from two or more control consoles are provided with busy lamps so that a control console supervisor will not attempt to connect to a trunk circuit already in use.

As pointed out before, one of the functions of the supervisor in charge of the control console is to get an indication of the condition of the toll positions under her jurisdiction. In addition to a "position supervision" circuit giving pilot lamp indications, access is provided to a monitoring circuit arranged for "listening in" on any toll operator within her unit. An outgoing trunk circuit to a two digit selector is provided for this purpose. The bank contacts of the selector are connected to monitoring access points on the toll positions. A "dry" monitoring circuit is employed, and is properly balanced to eliminate clicks on operation; in practice the clicks are almost impossible to detect. When the control console supervisor is monitoring in this manner, operation of a common positional talk key will permit conversation with the toll operator if desired.

Master Control Console

In large installations consisting of several operating units (each unit requiring a unit control console), it is often advisable to provide a Master Control Console common to all units. The unit control console has only the control equipment needed for the administration of its own operating unit; the supervisor in charge of the master control console, on the other hand, has control of functions affecting all of the units and, in addition, those functions enabling her to observe the other supervisors. This results in a simplified unit control console, as some of the infrequently used equipment required for all units is removed from the unit consoles and appears on the master control console.

An example of this is the toll circuit group control unit which is required per toll group. While all of the equipment required per toll group appears on the master control console (including over-flow, group busy, posted delay, group check, group OD, and route cut-off lamps in addition to busy check and OD check keys and a turn switch for selecting camp-on-busy, etc.), only a multiple appearance of the above-mentioned lamps will appear on the unit consoles. Thus, the actual functions controlling the toll circuit groups are performed at the master control console.

The master control console also requires more traffic indicating type meters than does a unit console, since the supervisor in charge of the master console should know the traffic conditions in each individual operating unit. An example of this is the calls-waiting meter indication. Each unit control console meter is wired in series with an individual calls-waiting meter on the master control console. While the unit control console receives information as to how many calls are waiting in the associated operating unit, the supervisor in charge of the master console will know the number of calls waiting in each individual operating unit.

Operator Training and Service Observation

By J. D. LOGAN
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So that the grade of toll service can be maintained at a high level, adequate facilities must be provided for training the toll operators as well as for checking on the speed and grade of service provided to the telephone user. With this in mind, special equipment was designed for use with the "FW-1" Automatic Toll Switchboard to provide the necessary training and observation facilities.

OPERATOR TRAINING

The "FW-1" Automatic Toll Switchboard is equipped with operator training facilities to give student operators some prior experience in the use of the key equipment and in the handling of the simpler types of calls, such as: regular and paystation C.L.R. calls, inward calls and calls to TX positions.

The teaching of more complex operations, such as delayed calls, point to point operation, etc., is deferred until after the student has obtained operating experience under actual traffic conditions. Student trainees are instructed in toll operating practices, ticket work and key set manipulation before instruction on the special training positions is commenced.

Equipment Features

Extra switchboard positions need not be provided exclusively for operator training. Groups of three regular positions can be equipped with special training facilities to allow an instructor to be seated between two trainees. By operating a special key, the regular traffic can be excluded from these three group positions while they are occupied for training purposes. However, during periods of heavy traffic, all three group positions are readily available to assist in handling the extra load. The position and link circuits are so arranged that all keys can be manipulated on the training positions and have the same significance as under actual traffic conditions.

Special training trunk circuits are provided, two for each of the training positions, including the instructor position. One of these trunk circuits can also serve as a regular interposition trunk to that position when not in use for training.

These training trunks appear on terminals of two-digit selector banks. In addition, these selectors may be accessed from levels of other selector banks so that the student may place training calls requiring the keying up of a larger number of digits.

Each training trunk circuit is accessible from four different contacts of the selector, thus bringing into use the various features of the circuit. The line and private leads of the four access

points are multipled but the pulse control lead is individual and marks the condition under which the training circuit is being utilized.

The training positions, including the instructor position, are each equipped with a special turn key which, when operated, prevents that position from receiving any calls other than those through the training trunks. In addition, the instructor position is also equipped with switching pads to demonstrate 5 db and 15 db circuits by a simple key operation.

The following are the types of calls which can be demonstrated by use of the different trunk access points:

Access No. 1 — ringdown and inward calls

Access No. 2 — TX calls, calls to local subscribers through the toll switch train, and calls to distant subscribers through the intertoll switch train.

Access No. 3 — regular C.L.R. calls.

Access No. 4 — paystation C.L.R. calls and TX transfers.

Method Of Operation

In general, training is conducted by teams of three operators, an instructor being seated between two trainees. Calls are originated by the instructor and received on the adjacent positions by the trainees. While such calls will be extended by the trainees back to the instructor position, due to the close association between the three positions the instructor can supervise visually all actions of the students and only a few special lamp signals will be reflected to the instructor. Besides direct observation, the correctness of key pulsing will be ascertained by the receipt of the call at the instructor position.

All calls originated by the instructor must be set up over the rear of a link. The instructor, therefore, must operate the dial rear key each time a training call is placed.

Regular C.L.R. Call

To demonstrate a regular C.L.R. call, the instructor keys up the proper code to reach the student position over the No. 3 access of one of the training trunks. Such a call should be received by the student with the position conditioned for automatic answering. The identity lamp on the student's position will remain dark, which identifies this type of call. The instructor can demonstrate switch-hook flash on the student supervisory lamp by operating a ringing key. The student receives disconnect supervision when the instructor releases. The instructor may give the student the necessary information whereby the simulated call can be extended back to the instructor position as if it was an actual call to a distant exchange.

Paystation C.L.R. Call

Paystation C.L.R. calls may be demonstrated in a similar manner to regular C.L.R. calls except that access No. 4 of the training trunk will be used when setting up the call. The student will receive paystation identification tone on answering and the identity lamp at the student position will flash at 30 I.P.M. to verify the type of call.

In conjunction with this type of call, the instructor may also demonstrate the various coin signals by means of a recording of these signals which is reached by keying a special code. To do this, the instructor first sets up the coin demonstration code on the rear of the student link, operates the positional rear cut off key and then sets up the paystation training trunk over the front of the same link. By restoring the rear cut off key, the recording is extended to the student, after which the cut off key may be re-operated. Upon instruction, the student may operate the coin collect rear or coin refund rear keys which will cause a momentary operation of the coin pilot lamp at the student position to indicate that the coin has been collected or refunded, as the case may be. The instructor may extend the length of the coin pilot signal by operating the check front key, which demonstrates to the student a stuck coin condition.

Ringdown or Inward Operator Call

Ringdown calls in either direction or inward operator (121) calls may be demonstrated by using the No. 1 access of the training trunks. The identity lamp at the student position will light to indicate this type of call.

On ringdown calls from the student to the instructor, automatic or key ringing may be used

as instructed. The interposition lamp at the instructor position will light after ringing is received, so that the instructor can check to determine if the correct procedure was used. After receipt of the interposition lamp signal, the call is accepted by the instructor whose position is in the non-automatic answer condition. Ring back signals will be received on the supervisory lamp as in regular traffic.

Calls to TX Operator

To simulate incoming calls to a TX operator, the No. 2 access of the trunk is used.

Calls Through Local Toll or Intertoll Switch Trains

Calls to local subscribers through the toll switch train, and calls to distant subscribers through the intertoll switch train, can be simulated by using No. 2 access of the training trunks. For such calls, the position may be set for automatic or key ringing as instructed. When ringing is extended, the interposition lamp at the instructor position will light to provide a check that the student followed instructions. The student will receive ring back tone until the instructor answers.

To permit a realistic demonstration, additional digits may be keyed before ringing is extended. The instructor may flash back to the student by operating the ring rear key. If the instructor disconnects first, the student may re-ring by operating the ringing key, which will re-light the interposition lamp.

Transferred Call to TX Position

To demonstrate the operation of a transferred call to a TX position, the instructor may extend a call to the student by No. 3 access. The student is then instructed to dial up a code which will reach the instructor position through the No. 4 access of the trunk. The instructor confirms that the right code was used by receiving a special tone. There will not be through supervision between the two links of the instructor position and the student will not receive a supervisory signal on the link until the instructor releases the trunk. This is the same condition that applies on a regular TX transfer call since the inward operator does not receive any supervisory signals until the TX operator disconnects.

SERVICE OBSERVATION

The principal purpose of taking service observations is to obtain data on the quality of service rendered by the operating staff. This information is obtained and appraised by trained observers at the service observation desk.

This new observation desk was designed especially for use with the "FW-1" Automatic Toll Switchboard and provides for the following observing and monitoring features:

Monitoring and supervision of toll recording and common battery trunks.

Monitoring and supervision of toll trunks.

Monitoring and supervision on position links.

Supervision of operator performance.

Monitoring through vacuum tube amplifiers.

Equipment for registering the digits keyed by an operator and displaying them on a special digit display panel.

Automatic speed of answer recording.

Front Equipment And Circuits

The desk is a one position, two-panel section, similar to a P.B.X. attendant cabinet. The jacks, lamps, cord keys and electric clock are located in the face of the two panels. The three cords are located on the shelf of the desk to the left, leaving sufficient shelf space for writing purposes. A double headset jack and a jack for the timer auxiliary control cord are mounted on the left side of the lockrail.

The left hand panel contains 40 jacks and associated lamps. The top 20 jacks may be used for observing on C.L.R., toll or common battery trunks. The lower 20 jacks are used normally for link observations; they may also be used for observing on C.L.R., toll or common battery trunks. Below the jack and lamp strips are located the cord keys, a release key and a timer start key.

The right hand panel contains a lamp display unit for displaying up to 14 digits, an electric stop watch with manual re-set which registers elapsed time up to 1000 seconds to an accuracy of 1/10 second, a jack strip for use when monitoring on a position and two associated lamp strips which provide miscellaneous signals in

connection with toll operator work in completing a call.

The position is equipped with three cord circuits and associated keys. Each of the first two cords are connected by their cord keys to variable gain, vacuum tube amplifiers. The third cord may be switched to either amplifier, depending on which of the two keys associated with this cord is operated.

A special double ear-piece headset is provided making it possible to follow the progress of a call separately on each of the two cord circuits.

The leads to the various trunk lamps, and the power to the amplifiers are controlled by relays and are activated when the observer headphone is inserted into its jacks.

Method Of Operation

C.L.R. Trunk Observing

C.L.R. trunks connected to the observation desk make use of a jack and two lamps. The first lamp is a "signal" lamp which lights as soon as the C.L.R. trunk is seized. The second lamp *hold lamp* lights when the trunk is connected to the operator position and stays lit as long as the trunk is busy. Supervision on the trunk is closed to the "signal" lamp.

Toll Circuit Observing

Toll circuits connected to the observation desk use a jack and three lamps. The "hold" lamp indicates that the circuit is busy. Supervision on an incoming call is shown on the "signal-in" lamp while supervision on an outgoing call is shown on the "signal-out" lamp.

Link Circuit Observing

Position link circuits may be connected on the observation desk to any of the 20 jacks in the lower part of the left hand panel. Each link circuit therefore uses two jacks and three lamps. The two jacks are for connecting to the front and rear ends of the link. One lamp is a "busy" lamp and indicates when the link is in use. A flashing "busy" lamp shows that the operator is in on the connection. The other two lamps will provide supervisory signals on the front and rear of the link.

Position Monitoring

The jacks, lamps and digit display panel in the right hand panel of the desk are used when it is desired to monitor on an operator position, but any two positions of a toll board can be chosen by the service observer. The lamps associated with the position monitoring trunks provide visual indications, for the observer, as to the condition of the toll position and the operation of the various keys. The digit display panel will register the numbers keyed by the toll operator when completing a call. Operation of the coin control keys, C.L.R. and TX cut out keys, ring key and cut in key at the toll position being monitored, will show as a lamp signal to the service observer. To extinguish the control and digit display lamps the observer operates the release key.

CONCLUSION

The incorporation of training equipment on the regular switchboard positions permits the preliminary training of operators under conditions closely approximating actual operating conditions and avoids the necessity of providing supplementary equipment.

The service observing equipment provides the necessary facilities whereby the grade of service received by a customer may be checked on a day-to-day basis.

TESTING FACILITIES

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It is generally recognized that equipment associated with operator toll dialing is considerably more complicated than that required for ringdown toll operation. Since an inward operator is normally not required, the interconnecting toll circuits must be capable of passing various types of control signals to and from the originating operator. In many cases, the switching equipment itself must perform functions which previously were the duty of the inward operator. In the "FW-1" Intertoll Switching System numerous new developments such as gate type incoming call distribution and four-wire switching, although highly efficient in speeding the flow of traffic and in improving transmission, nevertheless add to the overall complexity of the system.

This added complexity, as with all intertoll switching systems, would normally appear to increase the cost of maintenance. However, in designing the "FW-1" system, this fact was recognized and special attention was given to the development of testing facilities to simplify maintenance procedures. As a result, both loss of revenue due to circuit outage time, and maintenance costs, are kept to a minimum.

With the "FW-1" Intertoll Switching System, Toll Testboards and a number of specialized Test Boxes were provided, in addition to the test apparatus incorporated in the switching equipment itself. These are briefly described in this article.

TOLL TESTBOARDS

Separate primary and secondary toll testboards are provided in conjunction with the installation of the "FW-1."

The primary testboard provides means for analyzing line troubles on open wire or cable facilities and for testing telegraph circuits, whereas the secondary testboard is designed to permit checking the overall performance of dial and ringdown intertoll trunks, determining the nature and approximate location of faults.

Figure 53 is a typical toll circuit termination. It shows the method of cross-connecting the primary testboard jacks, toll terminal equipment, signalling facilities, secondary testboard jacks, and intertoll switching equipment.

The primary and secondary toll testboards are separate equipment arrangements each with a jack field, keyshelf and testing apparatus mounted on 23½″ relay racks. The testboards

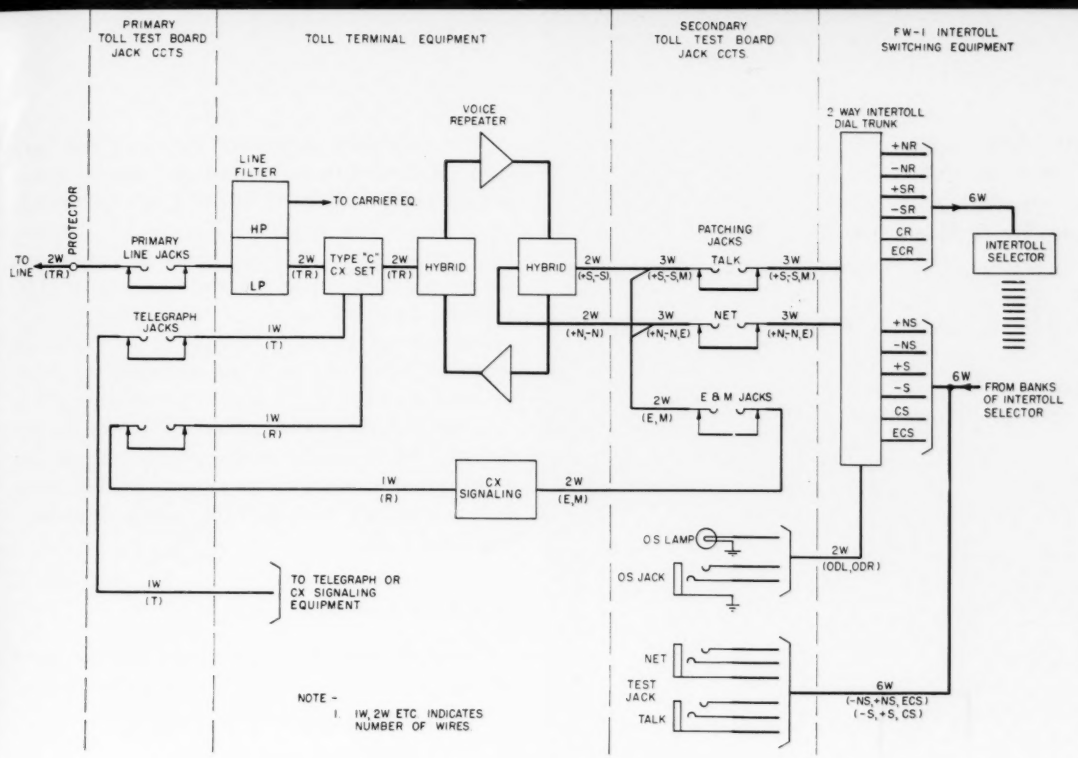

Figure 53. Toll Circuit Termination Showing Primary and Secondary Testing Jacks

can be operated independently of each other, or they can be switched together to form a single testing unit. The jack fields are made up of individual jacks mounted in jack mountings and cabled to the toll intermediate distributiing frame. Figure 54 shows the layout of a one-position primary and a one-position secondary toll testboard.

The following paragraphs outline the features and functions of each testboard.

Primary Toll Testboard (see Figure 54)

The primary toll testboard provides means for analyzing line troubles, for making voltage and current measurements, for locating faults with a Wheatstone bridge by either Varley loop or open location measurements, and for talking, monitoring, and 20-cycle ringing on toll lines and teletypewriter subscribers' lines. Primary line jacks on a 4-jack basis provide access to open wire, or to cable lines, for testing or patching of terminal and through toll circuits.

Telegraph testing facilities equipped include a volt-milliameter for line and loop measurement, and telegraph line jacks on a 2-jack basis. The line jacks provide an appearance between the telegraph legs of the composite sets and the line side of the telegraph repeaters or composite signalling equipment, for testing, patching, and monitoring purposes.

Secondary Toll Testboard

The secondary toll testboard is a centralized testing arrangement designed for the purpose of:

Determining quickly the nature and approximate location of trouble on intertoll trunks in order that immediate corrective action may be taken.

Making emergency substitution of toll terminal equipment and intertoll switching equipment.

Routine checking of the dialing, supervision, ringing, and transmission losses on intertoll trunks.

Providing access to individual toll circuits, and to special intertoll selectors, for testing and talking with other toll centres.

Incoming trunks from intertoll selector level 101 (toll test) and 2-way trunks from local

switching equipment terminate on the secondary testboard.

Testing Facilities (see Figure 54)

The secondary toll testboard is equipped with a jack field and two types of test cord circuits which have arbitrarily been designated as type A and type B cord circuits. Both types of cord circuits are arranged for monitoring, talking, dialing, ringing and transmission testing.

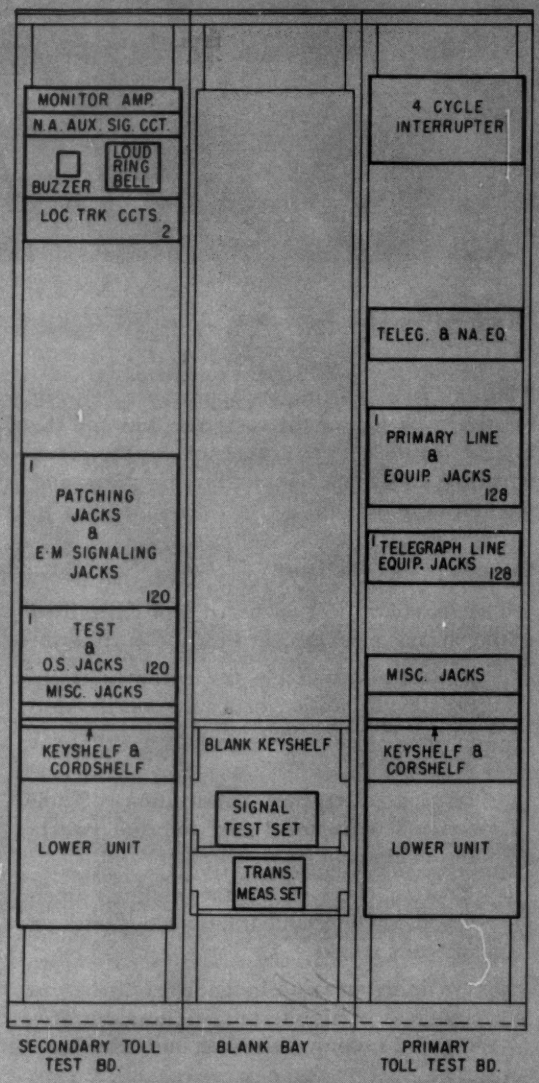

Figure 54. One Position Primary and One Position Secondary Toll Testboard

The principle difference between the two types of cord circuits is that the type A cords are normally only used in the event of trouble on a toll circuit to determine quickly whether the trouble is in the toll terminal equipment or in the "FW-1" switching equipment. The type B cords are arranged for testing from a point equivalent to the banks of the intertoll selectors. They are used for checking the overall performance of circuits, for routine testing, and for placing calls to other toll offices. In addition, the type B cords provide means for making busy tests, for seizing and holding busy intertoll trunks, and for originating or answering local calls.

Jack Field Equipment

The jack field of the secondary toll testboard is equipped with the following jack circuits:

Patching jacks

E and M signalling jacks

Test jacks

Out-of-service (OS) jacks

Miscellaneous jacks

Patching jacks. The patching jacks are double 3-conductor cut-off jacks inserted in the intertoll trunks ahead of the "FW-1" equipment as shown in Figure 53. The jacks are used for patching toll line equipment or "FW-1" switching equipment from one toll circuit to another and, together with the type A cord, circuits provide means for determining the approximate location of trouble on intertoll trunks.

E and M signalling jacks. E and M jacks, to provide access for patching and testing the signalling equipment, are connected into the signalling circuit of intertoll trunks using E and M leads. A signalling test set, mounted on a keyshelf adjacent to the testboard, is arranged so that it can be plugged into the E and M signalling jacks to measure the percentage break of the dial pulses received from either the toll line equipment or from the "FW-1" switching equipment, and also serves as a source of controlled D.C. pulses or supervisory signals.

Test jacks. The test jacks provide access to toll circuits at a point equivalent to the multiple of the intertoll selector banks (see Figure 53). They

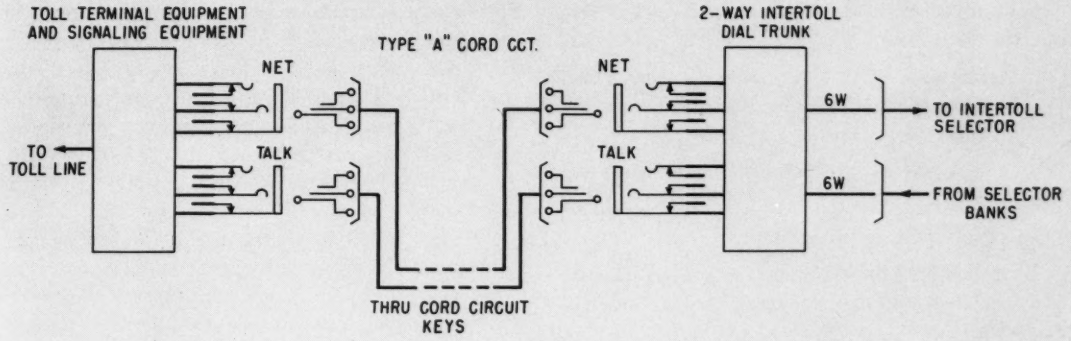

Figure 55. Type "A" Cord Circuit Inserted into a set of Patching Jacks

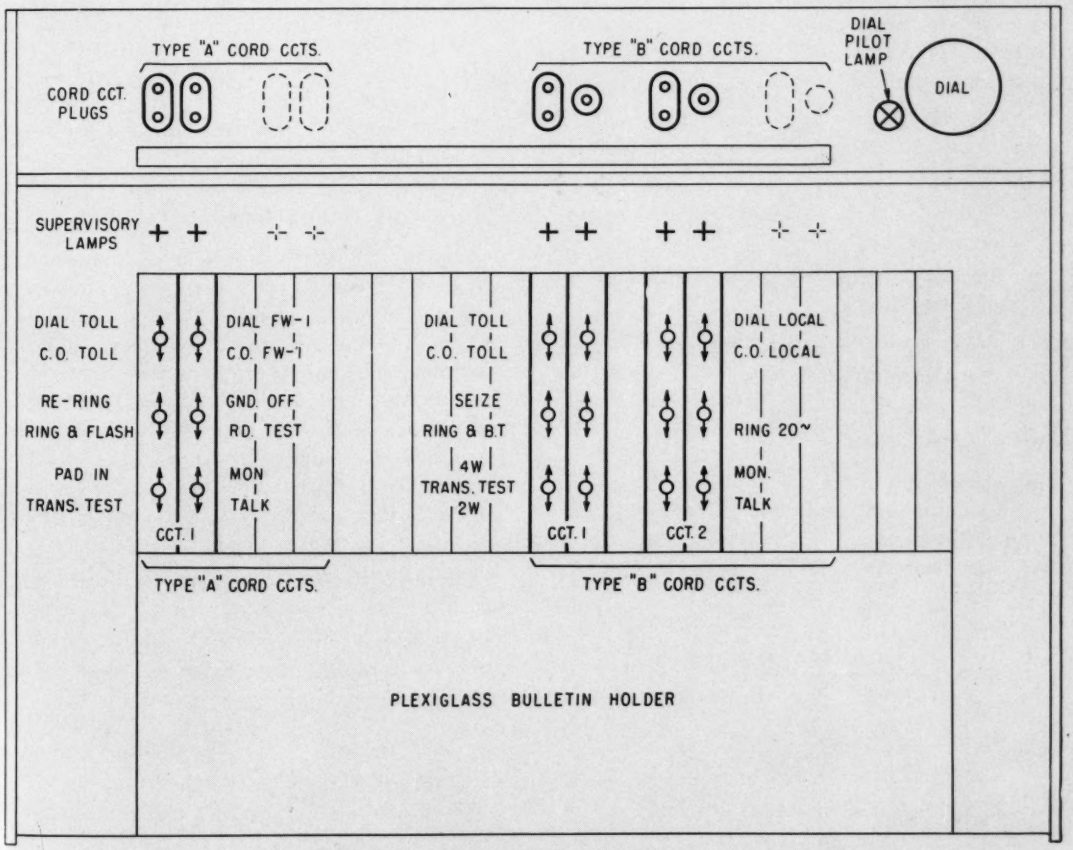

Figure 56. Keyshelf, Secondary Toll Testboard

are used in conjunction with the type B cord circuits to permit the toll test attendant to carry out the following:

Determine if a toll circuit is busy, and automatically seize the circuit when it becomes idle.

Check the overall performance of intertoll trunks.

Originate calls to other toll centres.

A tip busy test to indicate busy toll trunks was provided but visual busy lamps can be added if required.

Out-of-Service (OS) jacks. Each intertoll trunk is equipped with an out-of-service (OS) jack and lamp located on the secondary testboard. A shorted plug inserted into the (OS) jack removes the trunk from service and lights the corresponding (OS) lamps at the testboard, and at the switch positions. The (OS) lamp on the secondary testboard will also light whenever the trunk is taken out-of-service at the intertoll switching equipment.

Miscellaneous jacks. The miscellaneous jacks installed on the secondary toll testboard include the following:

Two-way trunks to local switching equipment.

Incoming trunks from intertoll selector level 101 (toll test).

Outgoing trunks to intertoll selectors.

Transmission testing jacks.

Type A Cord Circuits

The type A cord circuits are double-ended cords with double 3-conductor plugs at each end. The cord circuits are equipped with front and rear supervisory lamps and the following double-throw keys:

Monitor, Talk Key

Cut-off Toll, Dial Toll Key

Cut-off "FW-1," Dial "FW-1" Key

Transmission Test, Pad in Key

Ring and Flash, Re-Ring Key

Ringdown Test, Ground-Off Key

By inserting both ends of a type A cord circuit into a set of patching jacks of an intertoll trunk as shown in Figure 55, it is possible to monitor the trunk and at the same time observe the supervisory conditions on the trunk. Operating the cut-off toll key cuts off the toll line portion of the trunk, busies out the equipment at the distant end, and prepares the circuit for talking and testing toward the "FW-1" equipment. The cut-off "FW-1" key, when operated, performs a similar function except that it prepares the toll end of the trunk for testing and talking. The transmission test key transfers the talk and net leads from the circuit under test to special jacks in the jack field. Transmission measuring or transmission sending equipment can then be patched into the circuit as required. The ground-off key removes ground from the back contact of the M lead for use when dialing into certain types of carrier equipment. The type A cord circuits are arranged for testing toll dialing trunks equipped with E and M leads and for testing 20 cycle or D.C. ringdown trunks.

The secondary toll testboard is wired for two type A and three type B cord circuits, but one type A and two type B cord circuits are equipped initially. Figure 56 shows the keyshelf layout for the secondary toll testboard.

Type B Cord Circuits (see Figure 57)

The type B cord circuits are double-ended cords with a double plug at one end and single plug at the other. The double plug is the *toll* end of the cord circuit and the single plug the *local* end. The *toll* portion of the cord circuit is used for completing calls or testing to other toll offices, selecting an idle toll circuit from the test jacks, or for dialing up the toll circuit group from a jack appearance of special intertoll selectors. The *local* end of the cord circuit is used for answering or originating local calls.

The type B cord circuits are equipped with a toll and local supervisory lamp, and the following double throw keys:

Talk, Monitor Key

Seize, Ring and Busy Test Key

Cut-off Toll, Dial Toll Key

Cut-off Local, Dial Local Key

Transmission Test 4-Wire, Transmission Test 2-Wire Key

Ring 20 Cycle Key

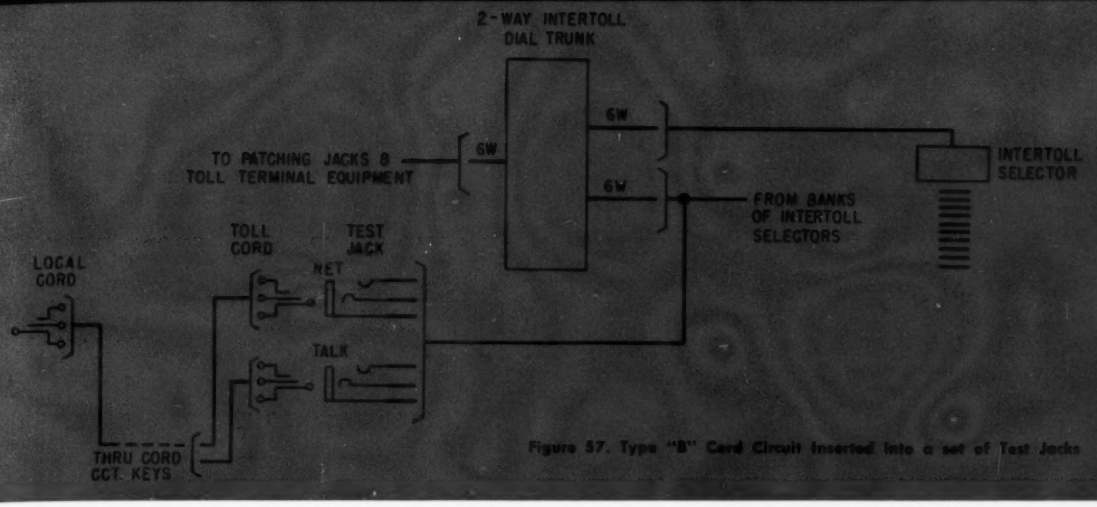

Figure 57. Type "B" Card Circuit Inserted Into a set of Test Jacks

The operation of the ring and busy test key prepares the cord circuit for tip testing the test jacks to find an idle intertoll trunk. If a particular trunk is desired, and that trunk is busy, the toll test attendant may then operate the seize key and insert the toll plug of the cord circuit into the test jack of the desired intertoll trunk. As soon as the toll circuit becomes idle and is released by the connected equipment, the type B cord circuit seizes the trunk and sounds an alarm to notify the attendant.

The transmission test 4-wire, and transmission test 2-wire key is used to check the pad control circuit of intertoll trunks, and simulates either a 4-wire or 2-wire connection.

The type B cord circuit can be used to extend a call from an intertoll trunk to a local line or vice versa. Operation of the cut-off toll key will cut-off and hold the toll end of a connection and the cut-off local key will cut-off and hold the local end of the cord circuit.

"FW-1" TEST CIRCUITS

Seven test circuits are provided with the "FW-1" system. One of these, the position and sender test switch, is a shelf mounted unit which is accessed through the special selector train, and the others are portable test boxes.

Position and Sender Test Switch

This circuit permits testing of all positional equipment and of the keysenders used in the "FW-1" system. Tests are conducted directly from the switchboard positions and the performance of the equipment is displayed on a set of 10 numbered lamps which are located in the switchboard panel equipment.

After the special service access code has been sent, any digits from 1 to 0 may be keyed in and will be registered on the corresponding display lamps. The operation of the checking, ringing, coin collect, coin refund, sender disconnect and cut-in keys may also be tested, each is identified by a two-digit display. Tests of line supervision; of the ability of a sender to recognize a stop-dial condition; and of the transfer of supervision which takes place on interposition calls, can be carried out and are recognized by a combination of a display and link lamp signal.

Test Boxes

The six "FW-1" Test Boxes include: a sender test box, link test box, trunk test box, A-B toll trunk test box, pulsing test box and a varying machine. The boxes are of metal construction and fitted with removable covers to protect the face equipment. A sturdy leather strap is fastened to each box so that it may be placed on a ladder and secured in position.

Connections between a test box and the equipment under test are made by means of ten conductor cords which are equipped with a multicontact plug on each end. When a box serves for testing two or more types of switching equipment, the internal test jack connections within the equipment are chosen such that like conductors appear on corresponding pins. This arrangement permits universal use of the cords.

Conditions imposed upon equipment by the test boxes are more stringent than those experienced under operation. Therefore, if a cir-

cuit meets the test box standards, its satisfactory performance in normal operation is assured.

Operational charts, which outline the test procedures to be followed, are supplied with each box. These charts indicate the order in which the test keys should be operated, and the lamp response which may be expected. Notes are also included on the charts, when applicable, which show any special connections required.

SENDER TEST BOX

The Sender Test Box is designed for testing the functions of both the impulse senders and the sender control circuits. It is equipped with a milliammeter which is calibrated to read both impulse speeds and impulse ratios.

Impulse Sender Tests

In addition to its application for indicating the impulse speed and ratio of the sender impulse generator, the test box may be used to check for correct sending, stop-dial, flash busy, posted delay overide and disconnect operation. A standard keyset and a set of ten digit display lamps (mounted on the box) allow the operator to key a series of digits into the sender and thereafter observe the display as the digits are spilled out. Causes of incorrect sending can be determined by repeating this operation while watching action of the sender digit storage relays, and associated control equipment. Stop-dial, and flash busy conditions are stimulated by manipulation of an appropriate key during sending.

Sender Control Circuit Tests

With the sender test box connected to a sender control circuit, a connection may be established through the control circuit and associated sender finder to an impulse sender. All operating features of the sender, such as sending, stop-dial, flash busy, posted delay overide and disconnect may now be checked from this point. Additional tests may be conducted to check the hunting action of the sender finder and the error erase, automatic ring, double stopping prevention and disconnect features of the sender control.

LINK TEST BOX

As its name implies, the link test box is used when testing the operating features of the position link circuits. In general, the operator is able to simulate all conditions encountered under normal operation and thus determine whether or not the link is functioning correctly by observing the supervisory lamps on the box.

The test man is able to set up an incoming call (on rear of link), answer the call, extend it over the front of the link, retire from the connection, re-enter, release either end of the link, extend the remaining connection to a new destination over the end thus released, or release the connection completely. Alternatively, he can simulate conditions which exist when a switchboard operator originates a call on the rear of the link and extends it over the front. Further tests can be conducted to ensure that a calling subscriber can flash the operator; that operator cannot release a connection from which she has retired, without first re-entering the connection.

When calls are passed from a C.L.R. or inward position to a T.X. position, the T.X. operator should receive supervision on both the front and rear of the link, whereas the C.L.R. or inward operator should receive *front* supervision only. The test box may be used to simulate calls of this nature and, of course, to indicate the supervision which prevails.

To facilitate testing of the transmission path of the link, the test box is arranged to provide transmission battery to a hand test telephone, and to extend the rear of the link through to this hand unit.

TRUNK TEST BOX

This is the most versatile of the "FW-1" test sets. Broadly speaking, it is suitable for testing all trunk circuits with the exception of AB Toll Trunks, which require a special box as described later. For purposes of this description, the circuits which can be tested with the trunk test box may be divided into the following 4 general classifications:

Trunks to Incoming Call Distribution.

Outgoing trunks to the local and toll switch trains.

Toll Line Trunk Circuits.

Intertoll selectors associated with the "FW-1" switching system.

Certain types of equipment, such as ringdown toll trunks, do not wholly fall into any of these categories but are a combination of two of them and can, therefore, be tested accordingly.

Typical functions of trunk circuits associated with incoming call distribution that the box may be used to check include: *stop* and *pass* action of the associated rotary switch; supervision; continuity of the voice transmission path; identity lamp operation; and operation of checking, pad control and coin control relays, where applicable. If desired, connections can be established from the trunk to a switchboard position and, with the assistance of the switchboard operator, the operation of the position links can be tested.

The other classes of trunk circuits mentioned above may likewise be tested in all their functions. When testing toll line trunk circuits, the signals may be extended to an operator or connector terminal in the distant office, if desired. If not, an alternative test procedure may be followed which permits testing the trunk circuit without operating the equipment at the distant end. The trunk is guarded to prevent incoming calls during this latter method of testing.

A-B TOLL TRUNK TEST BOX

Since A-B toll trunks may be arranged for either E and M or positive-negative signaling, a special A-B toll trunk test box capable of sending either type of signals, was constructed. Apart from this difference, and its relative simplicity due to its limited application, it closely resembles the trunk test box.

PULSING TEST BOX

Although designed in conjunction with the "FW-1" switching system, the pulsing test box may be used for pulse tests of any equipment employing battery, ground, or loop pulsing. A dial, mounted on the box, is provided to generate pulses and a pulse shaping network ensures uniform configuration of the impulses delivered to the equipment. If desired, an external pulse source (the Varying Machine, for instance) may be connected to the box, in place of the dial. Impulse speeds and ratios are indicated on a milliammeter equipped with both speed and ratio scales. This meter may be calibrated against either a 10 or 12 PPS ground input signal or against a 110 volt, 60-cycle input.

In order to facilitate tests of both the maximum and minimum allowable pulse ratios of the equipment being tested, two rheostats are provided, each of which can be set to give any desired output pulse ratio. Once the appropriate settings have been made, a lever key may be operated to transfer the output terminals from one ratio network to the other.

To avoid any errors which might be introduced by inertia of the meter movement, a biasing network is provided which permits the meter to be preset to the approximate value of the expected speed or ratio of the pulses being measured. Both maximum and minimum preset values can be set up, if desired.

VARYING MACHINE

Like the pulsing test box, the "FW-1" varying machine is also suitable for testing both local and "FW-1" switch equipment. Its primary application is for conducting standard *loop* and *leak* tests; however, it has 3 additional applications which should be noted. First, it can be arranged to pulse directly into selector vertical magnets (this feature is helpful in determining whether failure of a switch is due to a faulty pulsing relay or vertical magnet.) Second, it incorporates the elements of a C relay test set and can be used for this purpose. Third, it may be used as a source of continuous pulses, which is particularly convenient when impulse wave forms must be analysed.

A 110 volt, 60-cycle synchronous motor serves as the impulse generator of the unit. Master control keys are located on the box; however, a remote control switch which is attached to an eight conductor extension cord, permits control of the machine from a distant point.

CONCLUSION

Although only a brief discussion of the testing facilities is given in the foregoing description, it is apparent that convenient and exhaustive tests of the "FW-1" Intertoll Switching System and associated toll terminal equipment can readily be conducted with the aid of these devices.

AUTOMATIC TOLL TRUNK ROUTINER

By E. J. GLENNER

Project Engineer, Telephone Switching Systems Development,
General Telephone Laboratories, Incorporated

In recent years, the increased demand for telephone service has created great pressure for the development of a completely automatic nationwide toll dialing system. The trend toward operator toll dialing, and ultimately subscriber nationwide toll dialing, has introduced many additional problems including that of proper maintenance of toll and intertoll dialing facilities. With Direct Distance Dialing (D.D.D.) of toll calls by subscribers, no operators are present to supervise the connections and report trouble conditions. Further, with alternate routing of toll calls, this problem becomes increasingly difficult and important since a trouble condition in equipment in one office will not only affect originating and terminating calls but also, switched intertoll calls through the office.

It is therefore important that the intertoll dialing circuits and line facilities be kept in good working condition. To accomplish this, an Automatic Toll Trunk Routiner was developed to automatically test large quantities of intertoll dial trunk circuits and their line facilities. The automatic toll trunk routining equipment and connections are shown in Figure 58. Each intertoll dial trunk circuit in office A may be accessed from the toll trunk routiner circuit in addition to the normal selector access. Associated with the automatic routiner test circuit is a "primary access" rotary switch with bank capacity of up to 25 "trunk access" switches. Since a maximum of 50 or 100 intertoll dial trunk circuits appear at the banks of each trunk access switch, the automatic toll trunk routiner can access up to 1250 or 2500 intertoll dial trunk circuits. All intertoll dial trunk circuits in the same trunk group (trunks to the same distant office) appear on adjacent contacts of the same trunk access switch or adjacent trunk access switches.

The basic plan for automatic routining of toll trunks is simple. It assumes that all offices with intertoll dialing facilities will have test line equipment and, specifically, utilizes National Code "103" facility. Code "103" is one of several national codes that permits access of special test line equipment.

When an office is reached from any distant point, subsequent dialing of National Code "103" will access its "103" test trunk which will:

a) Return an "off-hook" signal to the distant office when the test trunk is seized.

b) Return an "on-hook" signal upon receipt of a ring forward (re-ring) signal from the distant office.

c) Return a 120 IPM signal to the distant office upon receipt of a second ring forward signal.

Automatic Routining

When it is desired to automatically routine all trunk circuits in each toll group within a toll office (say office A), operation of a *"set up"* key followed by a *"start"* key will initiate this action. The primary access switch is stepped off of its normal position to select the first trunk access switch, which in turn steps off-normal, selecting the first idle intertoll dial trunk circuit. When the trunk, *TB* in office B has been seized, the routiner in office A automatically pulses digits "1", "0" and "3" in succession to seize the "103" test line trunk (the pulses generated by synchronous motor similar to "FW-1" automatic toll board sender). This test circuit now returns an off-hook signal to the trunk circuit at office A; this signal is in turn passed back to the routiner.

When the initial off-hook signal is received, the routiner circuit automatically sends a timed ring forward signal (70-130 milliseconds) to office B. A test line circuit in office B returns an on-hook signal to the routiner through circuits *TB* and *TA*. When this supervision is received,

the routiner sends a second ring forward signal to office B. The test line circuit responds by returning a 120 IPM flashing supervision to the routiner through trunk circuits *TB* and *TA*. With receipt of this 120 IPM signal, the routiner releases the connection; this causes the trunk access switch to select the next idle intertoll dial trunk circuit. This procedure is again repeated using the newly selected trunk circuit.

After all trunks associated with a trunk access switch have been tested, the primary access switch selects the next trunk access switch and the routiner continues testing. Busy trunks are normally by-passed so that routining can be completed without waiting for busy trunks to become idle.

When the last trunk of the final trunk access switch is tested, the routiner returns to its "home" position and signals "end of test".

Circuit Failure

The routiner circuit provides a 15 second period (normal time) for completing a test. Since all signals from the routiner depend upon the correct signal being returned from a "103" test line trunk, faulty operation of the toll trunk circuits will prevent the test from being completed within the allotted time. The routiner will "time-out", stop the test, and sound an alarm.

Associated with the routiner circuit are "tens", "units" and "progress" lamps which advise the maintenance man regarding the circuit tested

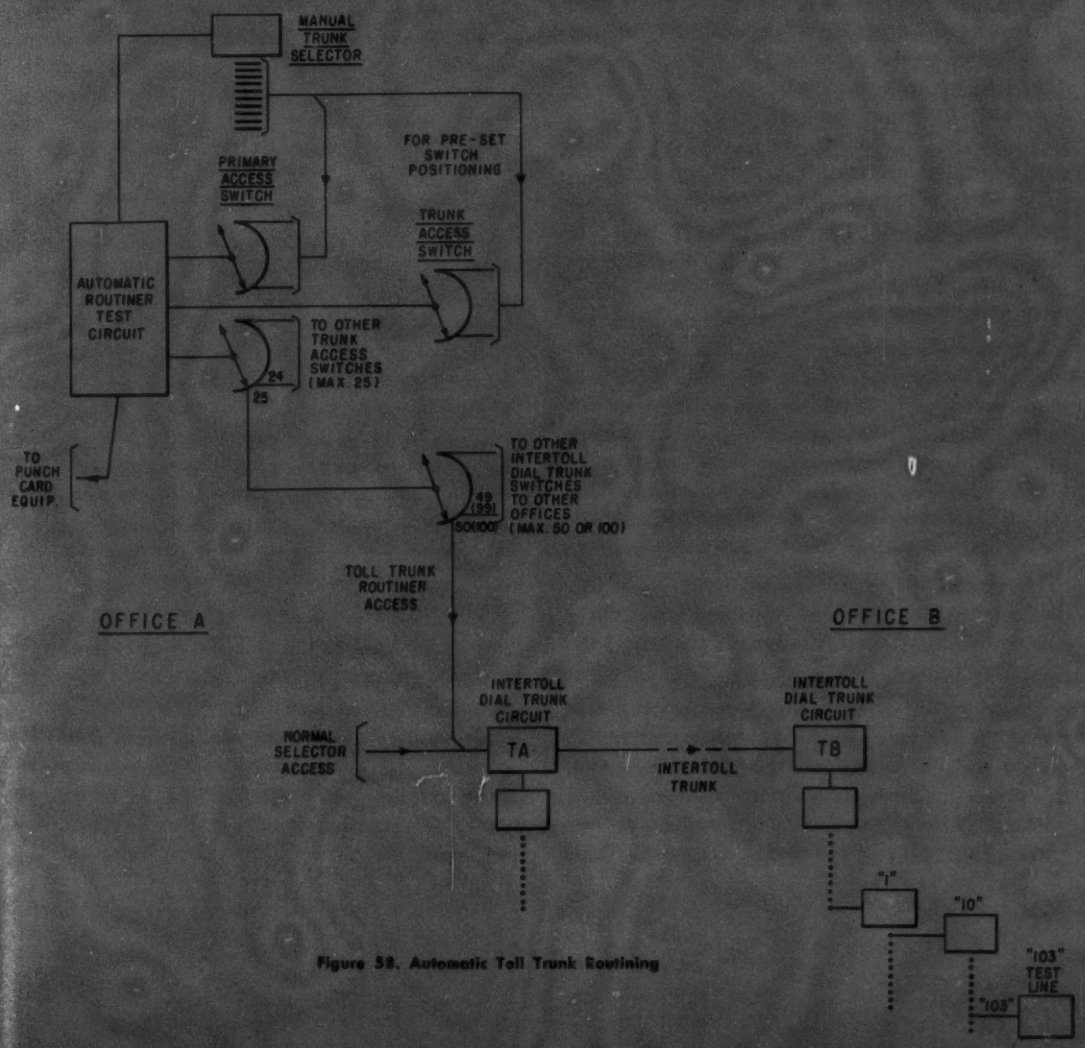

Figure 58. Automatic Toll Trunk Routining

and the point of failure of that circuit. Ten "units" and "tens" lamps each and 25 "switch" lamps indicate the number of the trunk circuit routined and the trunk access switch where it appears. The 25 "progress" lamps indicate at what point in the routining cycle the trunk circuit failed. Also, punch card equipment may be accessed which prepares cards indicating trunk circuits that failed, and the point of failure. When a card is prepared, the routiner circuit is arranged to automatically step to the succeeding trunk circuit and continue testing.

If a "103" test circuit is found busy, the intertoll selector will return flashing supervision to clear out the routiner, enabling it to continue its testing program.

Specialized Tests

In addition to routine testing, other specialized tests are performed. Assuming that a defective trunk is permanently busied out in a toll group, the trunk can be found by operating the routiner *"stop-busy"* key. With this key operated, when the trunk circuits are routined, the equipment automatically passes over idle toll trunk circuits and will stop at a busy one. The maintenance man can then determine if the busy circuit is legitimately busy or defective. Subsequent operation of the routiner *"step-on"* key will condition the routiner so that testing can continue.

Busy Circuit and Repeat Testing

The normal routining practice is to test only idle trunk circuits. However, if busy trunks require testing, the routiner *"camp busy"* key can be operated and the routiner will automatically wait for the busy circuit to become idle. A time-out circuit allows 6½ minutes for the busy trunk to become idle after which, the test is stopped and a "test delayed" alarm given.

If several test cycles are required on a particular trunk in a toll group, the *"repeat"* key can be operated for continuous routining of the same trunk circuit.

Operation of the routiner *"twice"* key will condition the routiner for automatic testing of each circuit a second time. After this second test cycle, the next trunk circuit is automatically selected. The routiner may be stopped by operating the *"stop"* key to permit the maintenance man to make observations on the routiner's progress and supervisory lamps.

Manual Trunk Selection

Each trunk group accessed by the routiner has been assigned an arbitrary two-digit code. Also, each trunk circuit within each group is assigned an arbitrary two-digit code. When a specific trunk group requires routining the *"set up"* key and *"routiner"* key are operated in sequence. The trunk group arbitrary two-digit code is dialed by the maintenance man from the routiner equipment.

The manual trunk selector (a two-motion switch) is positioned in response to the dialed digits to mark the trunk group and cause the primary and trunk access switches to find the desired trunk circuit group. At this point, operation of the routiner *"start"* key will start the routiner testing cycle.

To routine a particular trunk circuit within a toll circuit group, dialing of the trunk circuit group (as explained above), and the second arbitrary two digit code will select the exact trunk within the group. Operation of the *"start"* key now routines this trunk circuit.

Manual Trunk Testing

If a trunk circuit becomes defective, and the maintenance man wishes to make more complete tests than afforded by the regular routining procedure, the trunk circuit may be manually tested by dialing two sets of two digit codes as outlined above. A manual test and talking circuit is provided with facilities for dialing, ringing, talking and monitoring on the trunk. In addition, transmission keys give access to transmission test equipment permitting measurements to be made in conjunction with the selected circuit. This circuit provides many of the facilities provided by the secondary toll test board cord circuits discussed previously.

The manual test and talking circuit may be accessed from a line circuit for connection from a test desk.

A trunk to an intertoll selector from the manual test and talking circuit provides the maintenance man with facilities to set up any required connection from the routiner test equipment.

PULSING AND SUPERVISORY PERFORMANCE

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In the "FW-1" Intertoll Switching System it was desirable to obtain improved and simplified pulsing and supervision performance. To accomplish this, pulsing and supervisory functions were performed over an extra control (EC) lead without any connections to the talking conductors. Pulsing tests were carried out to determine the best combination of elements to provide reliable pulsing and supervision:

a) from sender to selector

b) from sender to intertoll dial trunk circuit (outgoing)

c) to incoming intertoll dial trunk circuit

d) from intertoll dial trunk circuit to selector

With pulsing and supervision performed over an extra conductor, apart from the talking conductors, a more desirable performance was achieved and, in addition, four-wire switching operations were simplified. Further, sources of transient disturbances on the talking conductors were minimized.

Elements of Pulsing (See Figure 59)

a) From sender to selector

With senders employed in the "FW-1" Intertoll Switching System, information must be reliably passed from the sender to the selector equipment. The prime impulsing device in the sender is a synchronous motor having interrupter springs pulsing at 10 PPS and 41% make. Battery pulses are passed from the sender to the selector —which has a ground connected pulsing relay on its incoming EC lead. To provide for good pulse repetition, the selector pulsing relay A1 must be quick acting. A low resistance battery connected relay in the sender will produce near saturation of the selector pulsing relay. In addition, the 250-ohm A1 relay has a relatively small number of turns so that its operation will not be retarded by high inductance. The sender supervisory E1 relay is shunted with a 300-ohm non-inductive resistance during pulsing. This further reduces the circuit inductance and provides improved operation.

Pulses originating at a sender with a value of 41% make, may be used to set up selector circuits or outgoing trunks to a toll switch train; both require a 41% make pulse. The sender may also provide pulses to an outgoing intertoll dial trunk circuit. In the latter case, if the percent make is increased at the intertoll dial trunk circuit to 42% make, the input at a distant point intertoll dial trunk circuit is reduced to 41% make, since the usual toll signaling circuits nominally lose 1%. The incoming pulsing relay (on the E lead) should reliably reproduce pulses so that selector and toll switching trunks in the distant office also receive a nominal 41% make pulse, just as would those in the originating office. This process could be repeated going through link after link with very little distortion in the pulses from the incoming to the terminating office.

b) From sender to Intertoll Dial Trunk Circuit (outgoing)

When the selector switches through to an intertoll dial trunk circuit, the pulsing connections are as shown in Figure 59. Relay A2 of the intertoll dial trunk circuit has a 250-ohm pulsing winding. Pulses to the intertoll dial trunk circuit are repeated to the toll circuit signaling equipment from springs of relay A2. The com-

bination of elements consisting of the sender E1 relay, sender impulse springs, spark suppression of 1 MF and 600 ohms, and low-resistance winding of relay A2, were chosen empirically to nominally produce a gain of 1% make from the sender impulse springs to the pulsing springs of relay A2.

c) To Incoming Intertoll Dial Trunk Circuit

At the contacts of relay A2 pulses are repeated to the toll circuit signaling equipment (which in turn introduces a nominal 1% make loss), and then to the incoming end of the intertoll dial trunk circuit (over the E lead) to pulse relay P2. Thus, the input pulse to relay P2 is 41% make, and it must be repeated without a phase shift.

One of the main requirements in designing relay P2 was to provide a good pulsing relay. It must produce a zero percent make distortion over a wide input pulse range and over wide voltage and line variations. Relay P2 has a typical pulsing relay adjustment with heavy gauge springs and a large screw residual. The coil has both low resistance and inductance thereby providing fast operation. Relay P2 normally operates at near saturation so that minor voltage variations will not effect its percent make output. It has a 300-ohm series resistance to limit heat dissipation and also to meet a possible future requirement of pulsing over the E lead with as much as a 500-ohm line. The 300-ohm resistor is required on a low resistance line of 0 to 200 ohms and strapped out on a high resistance line of 200 to 500-ohms. Thus, the pulsing relay will always pulse in series with a combined resistance of 200 to 500-ohms even though the line resistance varies as much as 0 to 500-ohms.

The relay pulsing characteristics over such wide line variations still remain within ¼% make variance. This negligible pulse distortion, in going from office-to-office, will permit successful pulsing to take place over several interoffice links.

d) From intertoll Dial Trunk Circuit to Selector

Battery pulses from the incoming intertoll dial trunk circuit are used to set up selectors or pulse trunks in the distant local office. The pulsing elements of a switching trunk are shown as relay A3. This relay must also successfully follow the pulsing contacts of relay P2. Relay A3 in this case, is very similar in its characteristics to A2. The battery connected relay of the intertoll dial trunk circuit No. 2 was chosen because it has a very low inductance and resistance which provides good pulsing characteristics. In addition, relay E2 is required to hold on the 250-ohm winding of A3 and release on both windings of relay A3 in series. This release requirement was met by utilizing a nickel-iron core and a large screw residual on relay E2.

Let us return, for a moment, to the intertoll dial trunk circuit in the originating office No. 1. Relay A2 has two windings and when an off-hook supervision or a stop-dial signal is received from the distant office relay P1 operates, placing both windings of A2 in series. The windings and margining of relay A2 were chosen so that with both windings in series, relay A2 will remain operated in series with the low resistance sender battery; however, relay E of the sender will release to give a stop signal to the sender.

In order to meet the above release requirements (similar to those of relay E2), it was also necessary to design sender relay E1 with a nickel-iron core and specify a large residual setting to facilitate its release.

This sender-selector pulsing arrangement is interesting due to a requirement that arose in connection with the selector pulsing relay. The selector pulsing relay is used to provide pulses to the selector vertical magnets (and rotary magnets on a two-digit selector) to step the switch in response to the dialed digit. The vertical (and rotary) magnets are energized when the pulsing relay restores during pulsing. When the vertical (and rotary) magnets operate, the vertical (and rotary) interrupter springs operate closing a holding circuit to a "modified" C relay. Since the magnets of a two-motion switch have an operating time that is far greater than their release time, the pulses through the switch interruper springs are shorter "clipped" than the pulses to the magnets. This gives a short percent make pulse to the "modified" C relay, thereby creating a marginal holding condition.

Because of the nature of the selectors used in

the "FW-1" Intertoll Switching System, it is imperative that the pulsing relay lose in the order of 7% to 10% make at its "make" contacts (gain 7% to 10% make at "break" contacts) to provide good pulses to the "modified" C relay. This large percent make loss at the selector pulsing relay contacts is achieved by using a cut-away armature and large residual screw setting in addition to heavy spring tensioning. This results in proper pulses through vertical (and rotary) interrupter springs.

Elements of Supervision

As pointed out previously, the supervisory functions in the "FW-1" system are performed over the EC lead, in addition to carrying out pulsing operations. A simple example of calling and called party supervision given the toll operator will serve to illustrate the manner in which call supervision is received. Each link of a toll position has front and rear supervisory relays (battery connected) corresponding to the parties at each end. These battery connected relays terminate at the front and rear EC leads connected to the link. When the front and rear parties are "off-hook", the EC leads will be connected to a high resistance ground circuit (or open) in the trunk circuits; the link relays remain non-operated. When either end is "on-hook" a low resistance ground on the EC lead operates the front or rear relay (or both), which lights the corresponding link supervisory lamp.

Basic elements of supervision as utilized in

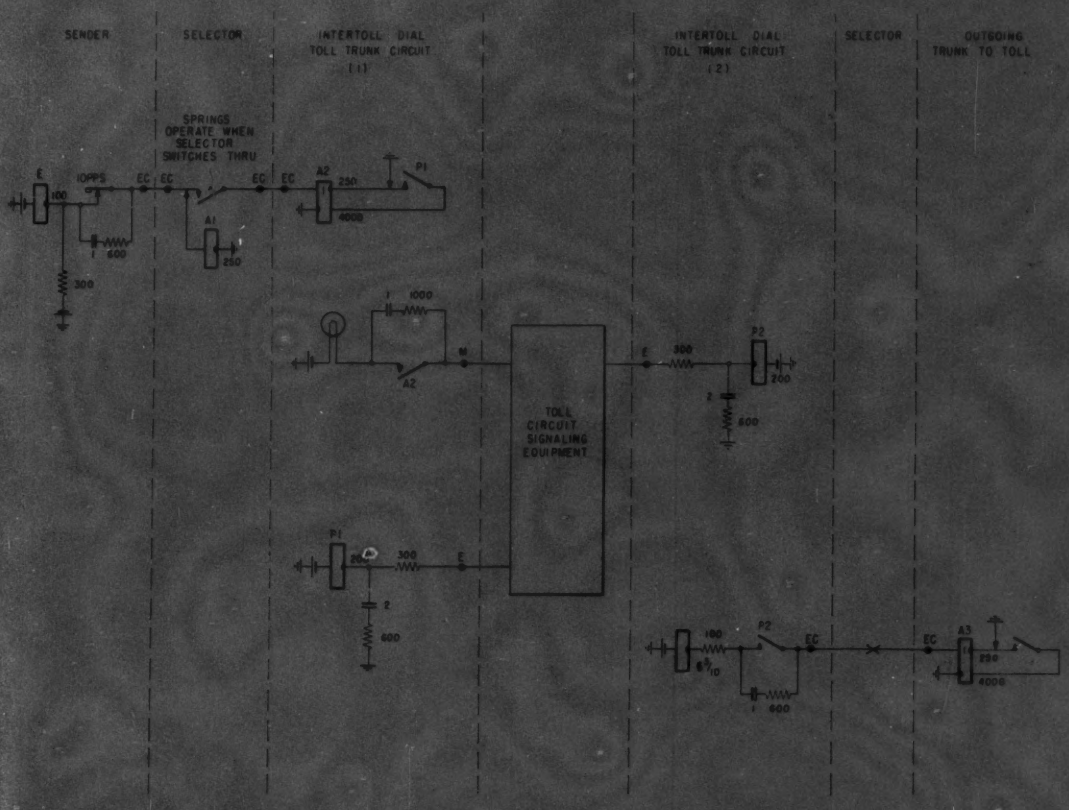
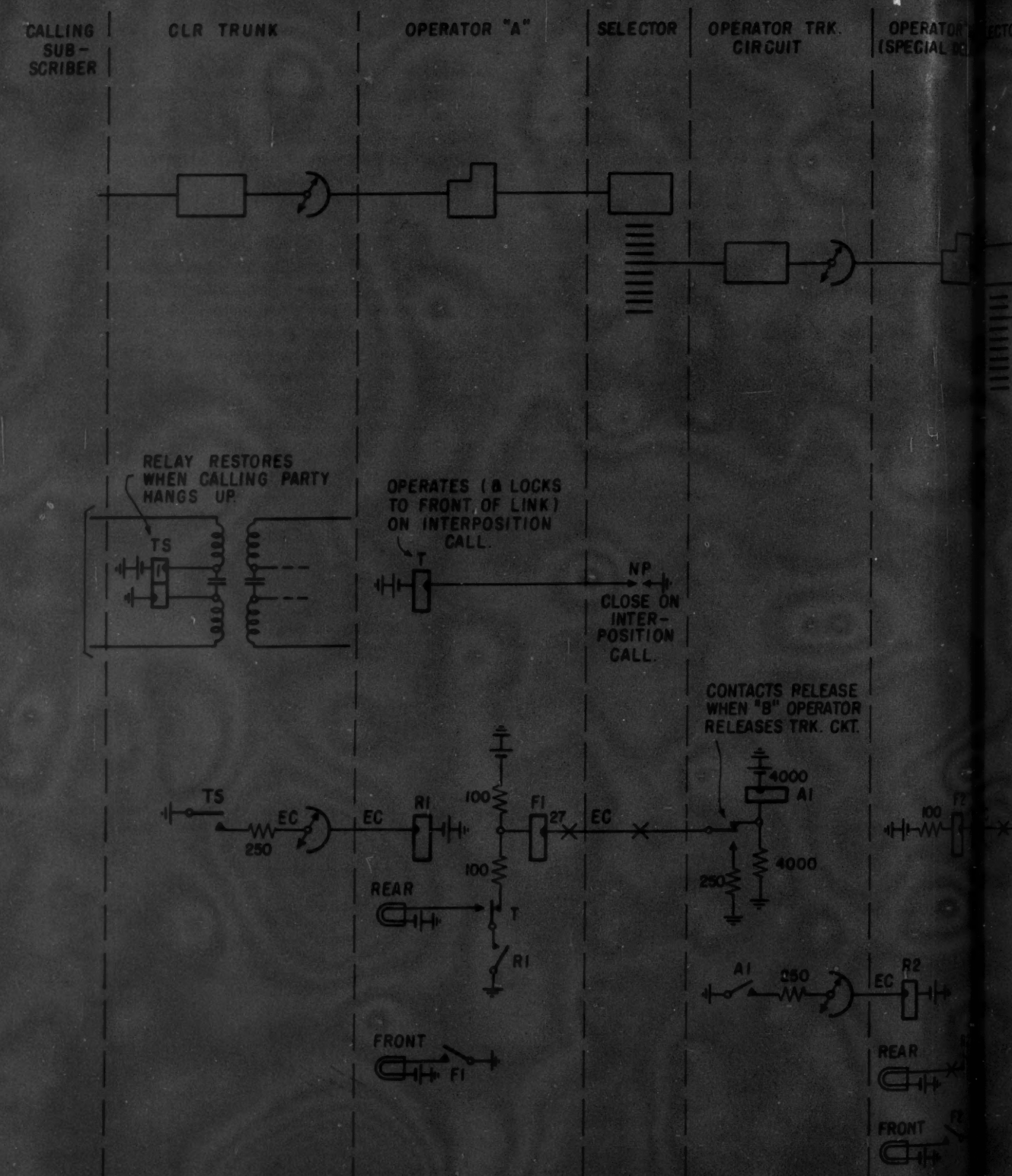


Figure 59. Elements of Pulsing—"FW-1" Intertoll Switching System


CALLING SUB-SCRIBER
CLR TRUNK
OPERATOR "A"
SELECTOR
OPERATOR TRK. CIRCUIT
OPERATOR (SPECIAL
RELAY RESTORES WHEN CALLING PARTY HANGS UP.
TS
OPERATES (& LOCKS TO FRONT OF LINK) ON INTERPOSITION CALL.
T
NP
CLOSE ON INTER-POSITION CALL.
CONTACTS RELEASE WHEN "B" OPERATOR RELEASES TRK. CKT.
4000
A1
TS
EC
250
EC
R1
100
F1
27
EC
100
4000
250
REAR
T
R1
A1
050
EC
R2
FRONT
F1
REAR
FRONT
F2

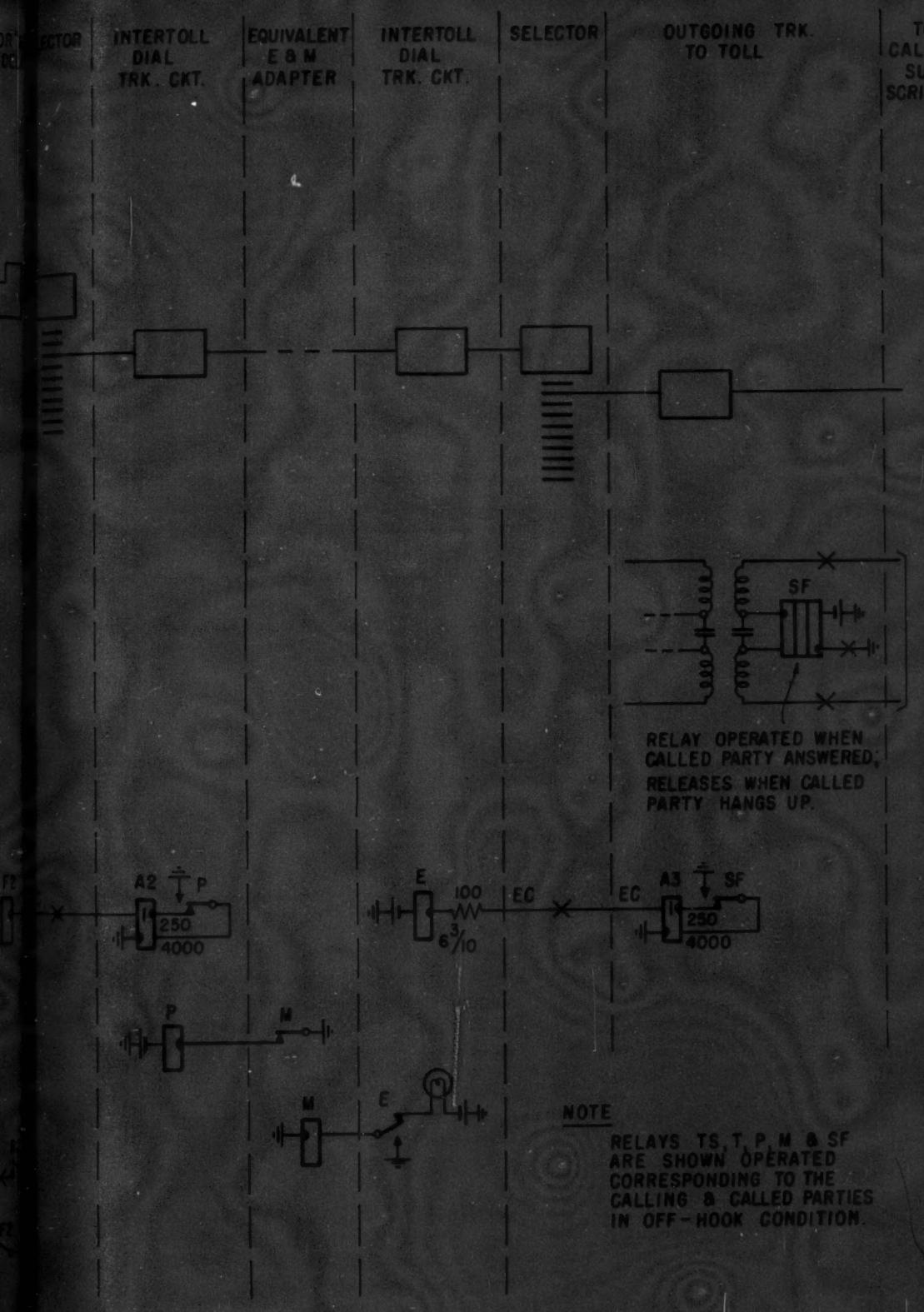


Figure 60. Elements of Supervision in "FW-1" Intertoll Switching System

the "FW-1" Intertoll Switching System are shown in Figure 60. In this block diagram, a call is traced from the calling subscriber to the CLR trunk ("O" level call) and then to the operator (operator A). Operator A can extend the call through selector equipment over an operator trunk circuit to a special delay operator (e.g. operator B). With this type of transferred call, the special delay operator is the completing operator and has complete control of the call. Since supervision of the calling subscriber is sent directly through operator A and given only to the special delay operator, supervisory functions are more complex than previously outlined.

When the special delay operator sets up the front of the link, the call is established through a link selector. If the call is intended for a distant office, it passes through the following equipment; intertoll dial trunk circuit, toll circuit signaling equipment (which is shown as an equivalent E & M adapter), the distant intertoll dial trunk circuit and its selector, then to toll switching trunk in the toll switch train and finally the called subscriber. Relays TS, T, P, M, and SF in Figure 60 are shown operated, corresponding to the calling and called parties in an "off-hook" condition.

To follow the calling and called subscriber's supervision, first assume that the called subscriber hangs up; relay SF restores in the toll switching trunk placing low resistance ground on the EC lead. This will operate relay E of the intertoll dial trunk circuit. Relay M is restored in the equivalent E & M adapter, dropping relay P in the intertoll dial trunk circuit. This again places low resistance relay A2 (of the intertoll dial trunk circuit) back to relay F2 at the special delay operator position. Relay F2 lights the front link supervisory lamp and the operator gets an "on-hook" signal from the called party (front of link).

Relay F1 in the A operator link circuit, and relay A1 in the operator trunk circuit, are both shown restored. Relay F1 cannot operate in series with 4,000-ohms; nor can relay A1, when shunted by a low resistance such as relay F1 and 100-ohms (total of 127-ohms).

When the calling subscriber hangs up, relay TS in the incoming CLR trunk restores, thus placing a 250-ohm ground on the EC lead to relay R1 in the link circuit of operator A. Since this was an interposition call, relay T in the link circuit of operator A has locked operated. This opens the circuit to the rear supervisory lamp so that operator A will not receive supervision. However, when relay R1 operates in the link circuit of operator A, it will close a voltage divider circuit in the link.

Relay R1 on operating places both sides of relay F1 at −24 volts potential. It can be seen that this represents a balanced Wheatstone bridge circuit with relay F1 in the hiatus of the bridge; thus, no current flows through relay F1 and it will not operate. On the other hand, relay A can now be considered merely in series with 4,000-ohms and it will operate. Relay A on operating closes a 250-ohm ground on the EC lead to relay R2 of the special delay operator thus lighting the rear supervisory lamp. Both calling and called subscriber supervision is given only to the special delay operator (operator B). Flashing supervision is passed on as described above.

When the special delay operator receives "on-hook" supervision for both calling and called subscribers and desires to drop the connection, the link release key is operated. This operation drops the front of the link to the called subscriber and also drops the rear of the link up to, but not including, the operator trunk circuit. Contacts as shown in Figure 60 are released by the special delay operator placing a 250-ohm ground on the EC lead back to relay F1 at the A operator link. This operates relay F1 which lights the front supervisory lamp. Thus, the A operator will get "on-hook" supervision from the called party and may re-enter the link to check conditions if required.

The A operator may be instructed to release the entire link on single supervision (from the called subscriber) or if desired, only the front of the link can be dropped. This will restore relay T, placing the rear supervisory lamp under control of relay R1. Now, with "on-hook" supervision from the calling subscriber, the rear supervisory lamp will light and the A operator knows that the entire connection should be released.

SUPERVISORY and SIGNAL CIRCUITS

By R. T. EVANS

Staff Engineer, Telephone Switching Systems Development, General Telephone Laboratories, Incorporated

The supervisory and signaling equipment associated with the "FW-1" Intertoll Switching System is shown mounted on two frames in Figures 61 and 62. The equipment consists of a number of separate circuits which convert 110-volts A.C. commercial power and 48-volts D.C. into various signals, tones and special power sources required by the system. In addition, alarm circuits are provided to detect irregularities in system operation, and cause visual and audible signals to be given when required.

Supervisory Circuit

The supervisory circuit serves as a clearing house for all alarm and supervisory signals which are generated within the toll office. Physically the circuit consists of about 20 relays, some alarm lamps, and a fuse panel. Alarm signal leads from the fuse panel, delay circuits, interrupter machine, and coin control power supply, etc., are connected to this circuit. The supervisory circuit detects the various alarm signals which it receives, causes the general alarm (audible) to sound, and causes appropriate identity lamps to light so that the location and nature of the alarm condition may be observed by toll office maintenance personnel.

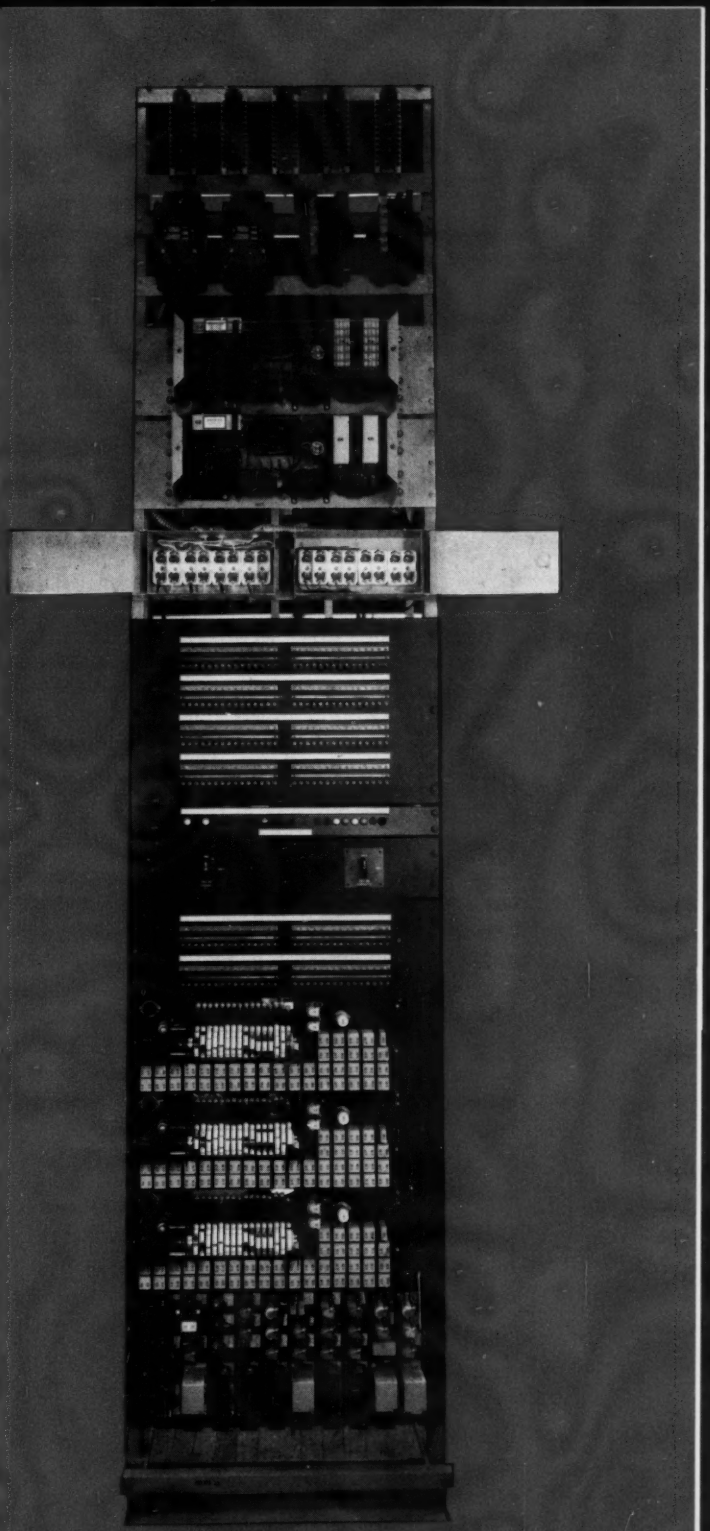


Figure 61. Supervisory & Signaling Circuit Rack Containing 24-Volt Power Transformers, Tone Machines, Coin Control and Interrupter Machines

Fuse Alarm Circuit

The fuse alarm circuit consists of several relays which receive alarm signals from the individual and common equipment fuses in the toll office. The circuit functions to relay alarm signals from the fuse panels to the supervisory circuit causing certain ceiling lamps to light indicating the location of the blown fuse.

Fuse alarms are considered to be of the "immediate" variety, since corrective action should be taken as soon as an alarm is received. Consequently, the signal is relayed to the supervisory circuit without delay.

Delay Circuits

Some alarm signals are classified as "delay" alarms. These are generated in the normal functioning of a circuit, and do not constitute an abnormal condition unless they persist beyond a specific length of time. Signals which can be classed in this category, are release and rotary alarms among others.

In other cases, a single alarm lead may be closed in an "overlapping" fashion by a number of different circuits, and result in a single prolonged signal. Delay circuits are then provided to cause an appropriate time delay before an alarm is given to the supervisory circuit. The length of this time delay is dependent upon the type of alarm given; it will vary from a minimum of 12 seconds for a Strowger switch release alarm, to a maximum of six minutes for some "permanent" alarms.

Distribution Fuses

Distribution fuses which supply 48-volt D.C. to all the equipment in the toll office (with the exception of the supervisory and signaling equipment) are located on fuse panels directly on the shelves with the equipment they serve. These panels contain a lamp which lights when a panel fuse blows. The alarm generated when a fuse blows is passed on to the fuse alarm circuit so that the general office alarm and location lamps may be operated.

Five fuse panels furnish power to and from the supervisory and signaling units. These are the main distributing fuse panel, supervisory

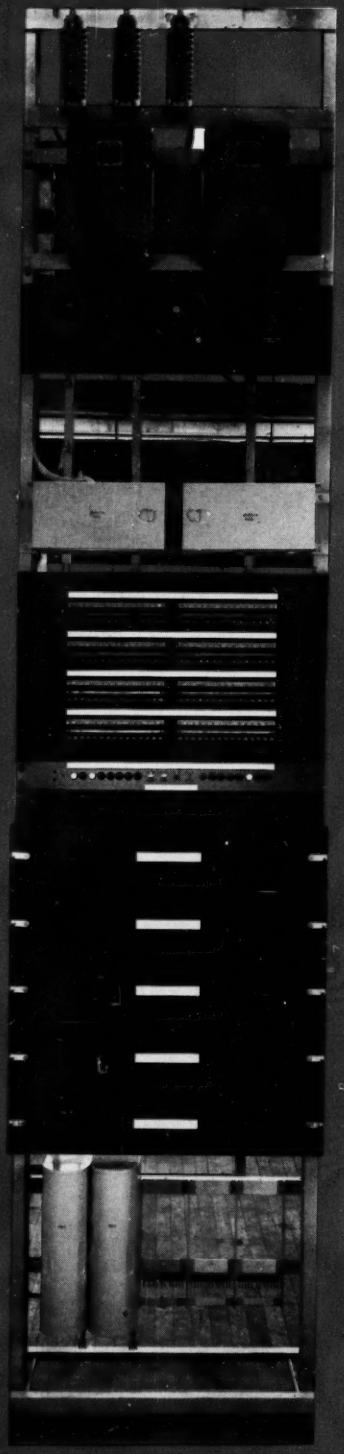


Figure 62. Supervisory & Signaling Circuit Rack Containing Ringing Converters, Alarm Bell and Delay Circuits

fuse panel, ringing fuse panel, coin battery fuse panel and the 24-volt A.C. fuse panel. The main distributing fuse panel contains fuses which distribute 48-volt D.C. to the supervisory fuse panel and the ringing fuse panel. The supervisory fuse panel contains fuses which distribute 48-volt D.C. and ground to the time-pulse generator circuits, coin-supply supervisory relays, delay circuits, alarm circuits and relays, and ceiling lamps. The ringing fuse panel contains fuses which distribute 48-volt D.C. and ground to the ringing-supply circuit, tone generator, supervisory lamp, and miscellaneous circuits. The coin-battery fuse panel distributes +110-volt and −110-volt coin-battery to the CLR and other circuits as required. The 24-volt A.C. fuse panel distributes power to the various synchronous motors used in the senders, etc.

Coin Control Battery Supply

Coin-control battery supplies are provided in duplicate. They consist of dry disc rectifier stacks powered from the regular or emergency 110-volt A.C. source. Under normal circumstances each supply actively meets approximately half of the total system requirement. Output of each unit is supervised. Visible and audible alarms are given in the event of failure, and the entire office is then provided with coin-battery by the remaining unit. Switch-over is accomplished by manual operation of cutout keys.

General Office Alarm

Power for the general office alarm bell is normally supplied from the regular 48-volt D.C. source. If the central-office battery or the general office alarm fuse fails, power for the alarm is supplied from the output of the coin-control rectifiers. Thus, the power source is independent of the central-office battery supply.

Pulse-Interrupter Machines

Compact, synchronous motor driven interrupter machines supply all basic timing pulses, flash-busy pulses and related signals. The machines mount on a base similar to a relay mounting strip. Each unit produces all the pulses which are required for the toll office. Additional units may be added for any purpose required by the growth of the system. Spare interrupter machines which are provided to replace those taken out of service for maintenance are connected by interchanging plugs and flexible cords. All impulses are supplied directly from the cam-driven interrupter springs.

Each interrupter unit is supervised; a self contained supervisory lamp flashes when the machine is running properly. If failure occurs, the general office alarm is sounded and the supervisory lamp remains lighted.

All interrupter springs are equipped with spark-suppressing devices. Should any of the capacitors in these suppressing devices fail, thus endangering the interrupter contacts, both audible and visual alarms will be given.

Time-Pulse Generators

Time-pulse generator circuits, furnished in duplicate, provide timing pulses which are required to operate the various delay circuits, release alarm, rotary alarm, etc. Each circuit consists of a number of "flip-flop" relay pairs which convert a basic 10 IPM timing pulse (from the interrupter machine) into timing pulses of 12-36 seconds, 48-144 seconds or 96-288 seconds. These timing pulses are furnished to the various circuits through distributing relays. Every 12.8 minutes a one second pulse is supplied to the call waiting signal circuit of the control console.

Tone Machines

Duplicate machines supply the tone needs of the toll office. Each machine has a separate "on-off" power switch; a separate lever key connects the output of the machine to the distributing transformers. The control circuits are interlocked so that outputs of both machines may not be connected to the distribution transformers simultaneously.

Neon-type lights indicate which tone machines are running; supervisory lamps indicate which machine is supplying tones to the office. A portion of the machine's output is connected

to the springs of the interrupter machine to obtain the required interrupted tones. These tones are synchronized with appropriate flashes when necessary, eg. 120 IPM and busy tone.

Ringing Machines

Two ringing converters (Subcycle) furnish the 20-cycle ringing power to the toll board. Output of these two units are connected to the various circuits through distributing fuse panels. Dry direct generator, ground-connected direct or ground-connected interrupted generator, are supplied to the trunk circuits as required.

The output of each generator is supervised, both audible and visual alarms being given in the event of a failure. These alarms are "locked in" and must be released manually, even though the failure may have been only momentary.

Cut-out keys are provided for each unit, to disable the associated convertor and transfer the total office load to the remaining unit. A supervisory lamp remains lighted as long as a cut-out key is operated.

24-Volt A.C. Power

Two transformers provide 24-volt, 60-cycle power to the synchonous motors used in the senders, register senders, service observation board, and traffic recording equipment. Switches (manually operated) permit the entire office load to be shifted to one or both of the transformers. Visual and audible alarms are given in event of failure of the units, and the supervisory lamps remain lighted as long as one or both units are out of service.

Delay Announcer

A magnetic-drum recording device, equipped with five pick-up heads, is provided to furnish verbal circuit delay announcements.* A total announcement cycle consists of 6.7 seconds, with 4.7 seconds devoted to the recorded announcement, and 2 seconds to a special flashing signal. A signal flashes the appropriate link supervisory lamp to call the operator's attention to the delay announcement.

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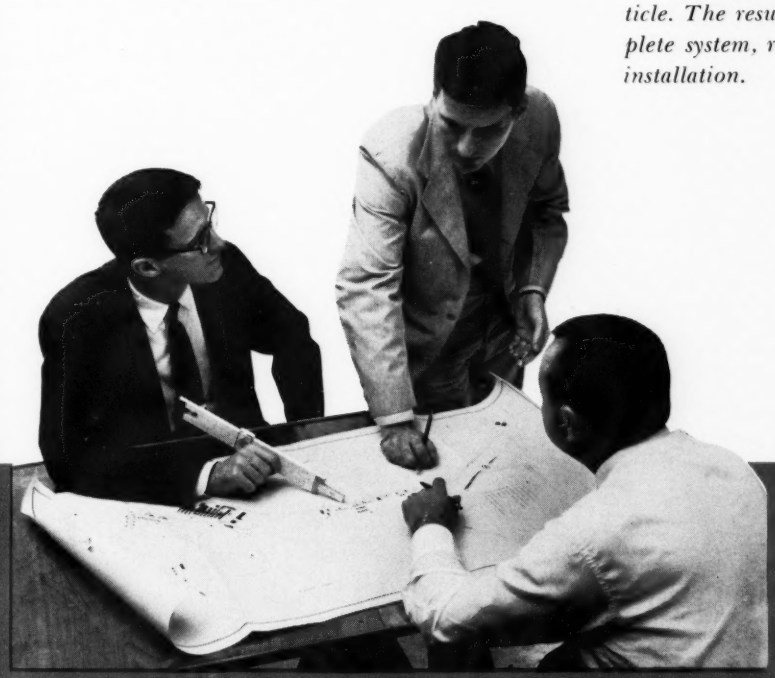
* (see "Camp-On-Busy Circuits"—Technical Journal, December, 1956 issue.)

PHYSICAL FEATURES and CROSS-CONNECTIONS

By FRANK A. GHISELLI

Manual Equipment Engineer, Automatic Electric Company

When the many circuit elements of the "FW-1" system had been designed, as described in the preceding articles of this series, the circuit designer had substantially finished his work. It then became the task of the equipment designer to translate these many circuit elements into physical form, and to design mounting facilities for them. Finally, the systems, or equipment, engineer had to specify the proper types and quantities of equipment units, and the necessary connections between them. The contribution of the equipment designer and the equipment engineer to the "FW-1" system will be discussed in part, in this final article. The result of their efforts was a complete system, ready for manufacturing and installation.



PHYSICAL FEATURES

The equipment of the "FW-1" system was designed to meet a combination of many requirements: economy, durability, good appearance, compactness, weight distribution, and simple maintenance—to name just a few. The equipment can be considered in two categories —the toll switchboard or operator positions, and the automatic switching apparatus, including that associated with the toll switchboard.

The toll room floor plan of a typical "FW-1" switching system with a 192-position toll board initially is illustrated in Figure 63. An actual installation of this size requires switching equipment providing 60 toll trunk groups totaling 1100 toll trunks, 850 toll transmission trunks, 600 CLR trunks, 400 miscellaneous trunks, 6000 intertoll selectors (toll, link, and dial rear) and the regular positional equipment and asso-

ciated circuits. Growth of well over 100% is allowed for an installation of this magnitude. Because of its size, a floor plan is not shown for the associated switching equipment.

A schematic diagram of a typical switching plan for the "FW-1" system, which shows the interconnection of circuits, is illustrated in Figure 41, page 126 of the December, 1956, Technical Journal.

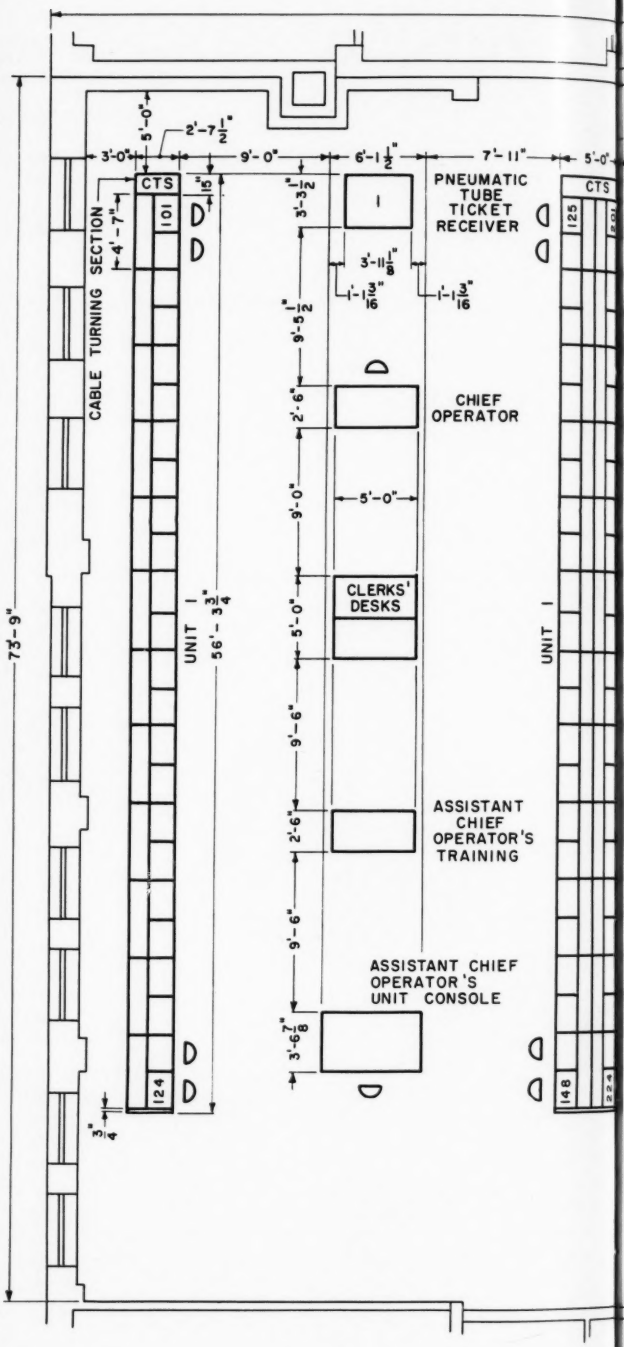
The "FW-1" Toll Switchboard can be divided into segregated positions (normally inward, CLR and TX) or there may be universal or combination positions which will handle one or more of these classes of calls. Regular switchboard positions can be equipped as required for operator training purposes.

Toll Switchboard Positions

A typical lineup of toll switchboard positions, placed back to back, is shown on the front cover of this journal. In a large toll office, double-sided line-ups in units of 48-positions (twenty-four positions, back to back) will generally be used. Single-sided equipment may be provided in smaller exchanges, or when placing positions along a wall.

The modern trend is to design switchboards to resemble office furniture, suggesting clerical working conditions. This toll board, with its exceptionally low lamp-jack panel, the absence of cords and plugs, and the very small amount of multiple cabling between positions is readily suited for this styling. In fact, it would be possible to arrange the switchboard positions in small groups, to suggest business machine units and thus attract more personnel to the telephone office. Most attractive also are the variety of colors that are now available on switchboards to match current office color schemes. The exterior woodwork is usually mahogany; however, oak, walnut, birch or any other suitable wood can also be supplied.

Since the associated switchboard link and position relay equipment is not located within the switchboard, and because the lamp-jack panel is small and cabling at the switchboard is relatively light, the cabinet has been made very compact. This saves floor space in the toll room. The elimination of cords and plugs simplifies manual operating procedures and results in less



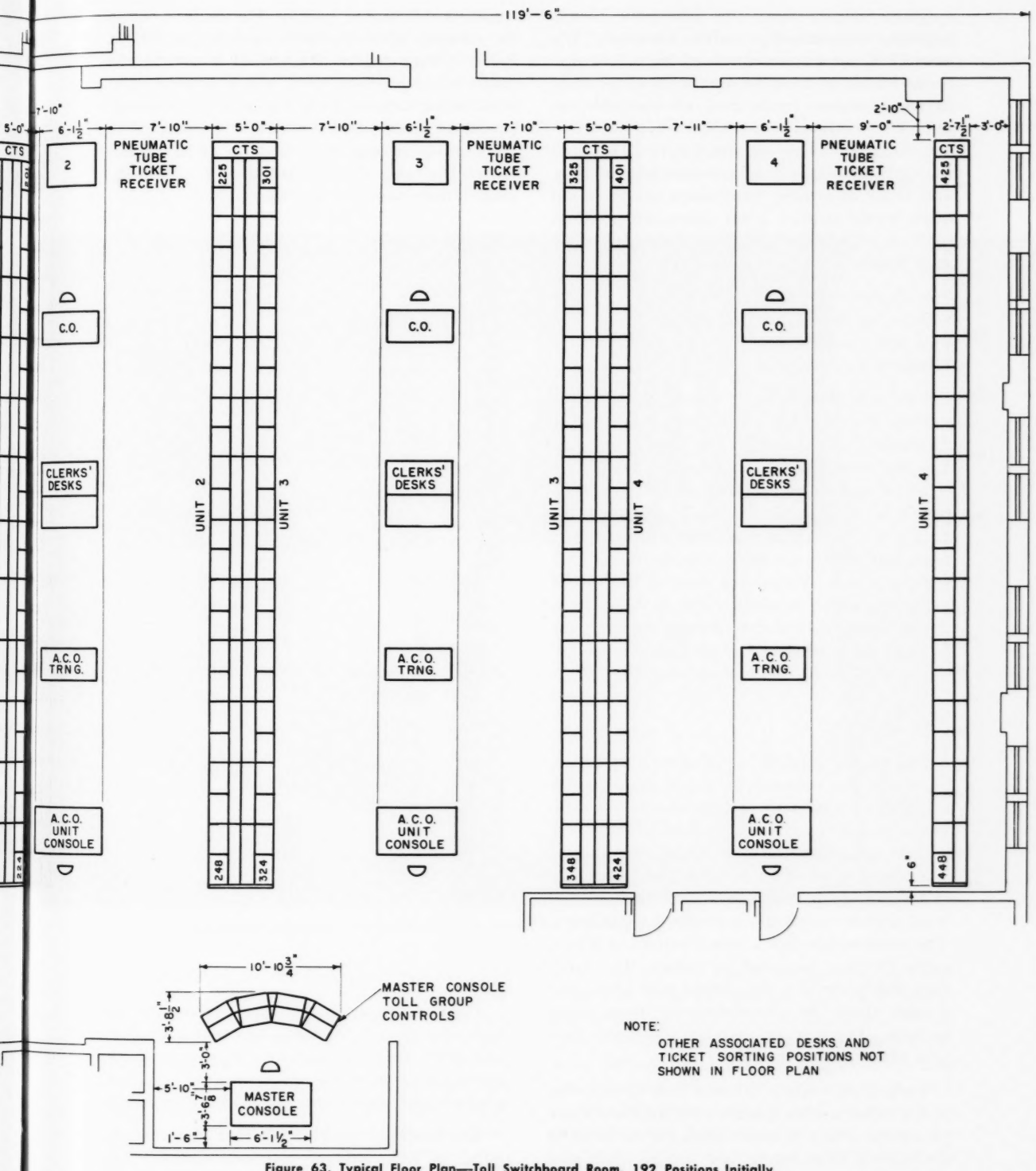


Figure 63. Typical Floor Plan—Toll Switchboard Room. 192 Positions Initially

operator fatigue. Since the calls come into a position automatically (with automatic key answering) and are announced by a "zip-zip" tone, there is no need for operator's surveillance of trunk answer lamps, and no possibility of double connections caused by two operators seizing the same trunk simultaneously. This permits greater efficiency in the handling of calls, and faster answering time. As a result, a toll office would require fewer operators' positions with an automatic toll board than with a cord-type board.

With the absence of cords, plugs and pulley weights, the key shelves are made lower so foot rails are abandoned. Conventional Masonite kickmats are furnished.

The switchboard units come in 2-position sections with sloping turrets for single-sided or double-sided lineups. The woodwork is attached to a unit steel frame, giving form to the switchboard. Common to a section are the turret-jack panels — the smaller capacity switchboard equipped with two, and the larger with four. The 2-position section on both switchboards is 4′-7″ wide, and 3′-8¼″ from the floor to the top of the turret, with a keyshelf height of 2′-6½″. On double-sided lineups the distance between the front of the keyshelves in each lineup is 5′. On single-sided lineup depth of the board is 2′-7½″.

a) *Keyshelf*

The hinged keyshelf, as illustrated in Figure 65, shows the common keys and lamps which comprise an operator's position circuit, the individual link keys and lamps (a total of seven link circuits equipped and eight wired), keyset and Calculagraph common to two positions. New multi-colored, plastic, lever key handles and lamp caps are mounted on standard escutcheons. The latest square faced, keyset buttons of plastic mold are also furnished in colors. The lamp caps which are of a new design with extra protrusion above the escutcheons can more easily be seen. The new key handles and keyset buttons make operation easier.

Twin ticket-pockets between link escutcheons, and a ticket storage space on the keyshelves, are provided. There is ample space on the keyshelf for bulletin information, and also an additional multi-card bulletin holder. The bulletin space is covered with Plexiglas, which provides a good writing surface; the keyshelves are covered with black phenolic fibre which gives a hard and lasting surface. Each position keyset through associate sender finder switches is common to two groups of senders having up to 25 senders in each group. Between positions is a call-timing device, usually a Calculagraph.

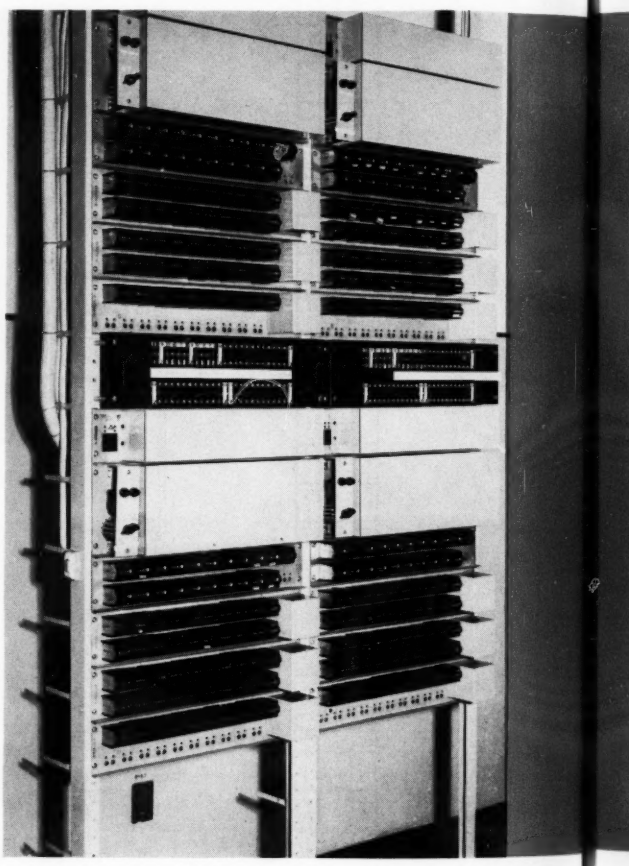


Figure 64. Trafficorder Equipment

b) *Turret Lamp-Jack Panels*

Turret lamp-jack panels are common to the following circuits for every two positions: Position pilot and class-of-service lamps, group busy, group and line check and posted delay lamps, position and sender test and sender busy lamps.

The lamp-jack panel is different from the jack panel of the cord-type toll switchboard. The

latter requires an extensive jack field of multiple trunk-circuit appearances, through which all trunk-circuit connections can be established. A full complement of all trunk circuits must appear within reach of every operator in the cord board, yet the operator can connect only as many trunk circuits, at any one time, as are allowed by the number of position cords—usually about seven in a combination position. cord toll board jacks represent from 5% to 20%, or more, of the cost of complete toll switchboard equipment (including the cost of all trunk relay circuits having termination at the switchboard), and this percentage rises as the switchboard positions increase in number. Eliminating the jacks is probably so radical a change in toll board practices that its significance is only slowly being realized.

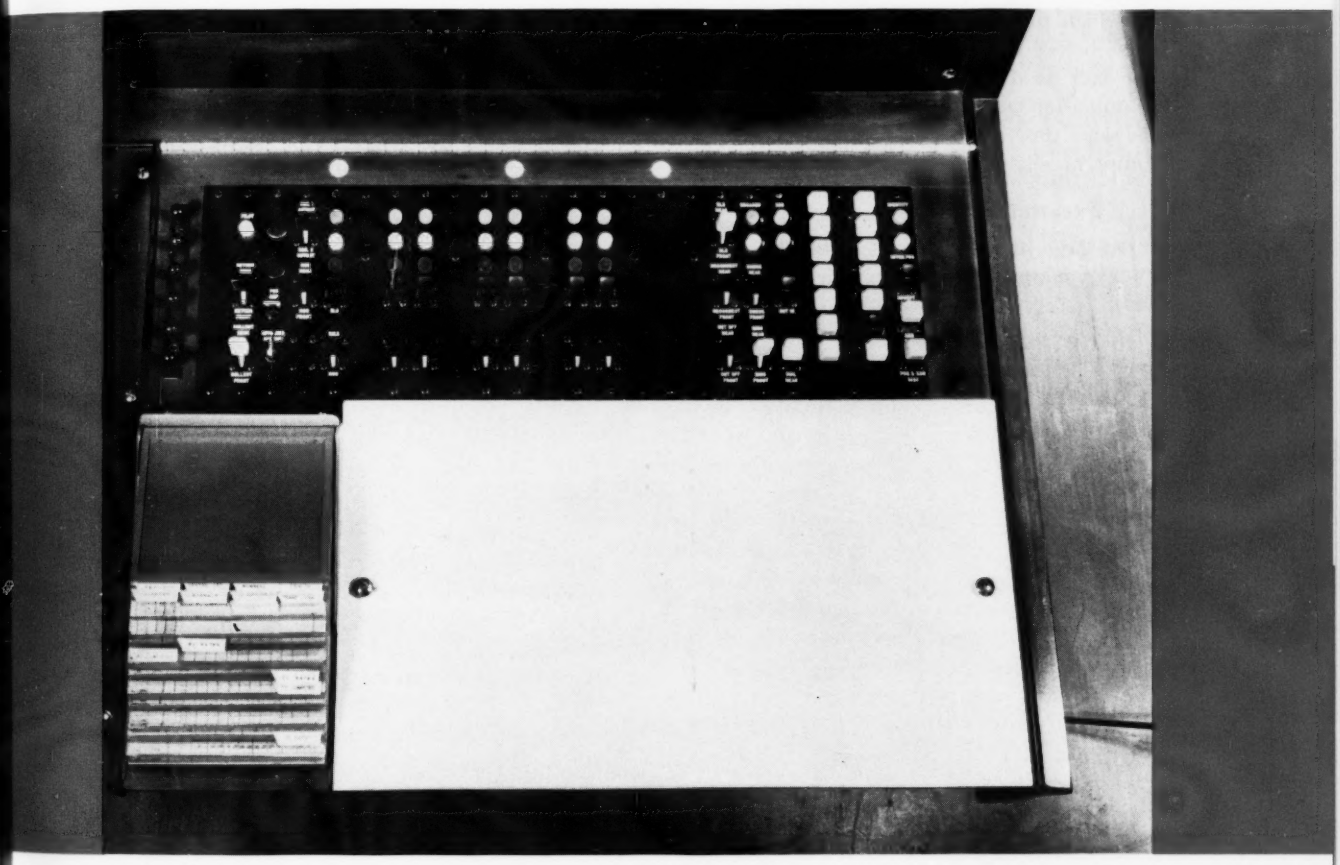


Figure 65. Automatic Toll Board Keyshelf

The principle of the "FW-1" Automatic Toll Switchboard is to extend position links (the equivalent of cords) to the trunk circuits at a remote point, and by making use of automatic switching, prepare the trunks to select the position links. In this way the whole multiple jack field and multiple cabling is eliminated, and in its place from the switchboard, there is only the cabling of the link circuits. It is estimated that

The group busy, check and posted delay lamps associated with the various toll trunk groups are located in units of three lamps to each toll group, on 20-per-strip combined designation and lamp jack strips. The trunk groups, other than the toll trunks, have only associated trunk check lamps. The group busy lamp will light when its associated toll group is busy thus giving the operator supervision over the toll trunk groups

at all times. The group checking lamp enables any operator to determine the trunk group that is occupied. Deflection of a check key causes the group check lamp to light, identifying the engaged trunk group, while a "tens" and a "units" lamp will light, giving the exact trunk number in the group. A faulty trunk can be quickly identified, and the condition reported to the wire chief. The posted delay lamps are operated by the control supervisor to indicate on which toll groups there will be a period of delay before the toll call can be attempted. The low jack field is an aid to better switchboard illumination and toll room ventilation, and at the same time there is less heat dissipation, since comparatively few lamps are employed.

c) *Pneumatic Tubes*

On large installations, the cabinet is designed for a pneumatic tube system for distribution of toll tickets.

Switchroom Equipment

The switchroom equipment may be divided into six main categories, namely: the incoming call distribution circuits (comprising the primary and secondary rotary switches); the position, link, sender control, sender finder and sender switches; the intertoll, link and dial rear Strowger step-by-step 100-line selectors and dial rear finders; the many different trunk circuits, out-going secondaries and alternate routing equipment; the miscellaneous control and supervisory circuits; and the ringing and supervisory panel and power board.

Switchroom equipment resembles regular telephone switching equipment in a central office, but upon closer examination will show certain adaptations, such as "twin" distributing-type terminal assemblies for the selectors, the use of selector-type distributing terminal assemblies for the primary rotary switches of the incoming call distribution, and the use of jumper-type shelves for jacked-in switches for practically all of the circuits, with the exception of rotary switches, supervisory and control circuits, and the trafficorder equipment (see Figure 64).

The twin terminal assemblies for the selectors are the result of requiring 600-point selector banks to include the + line and − line leads, the C and EC leads, and the + net and − net leads which make up the second pair of wires in the four-wire switching system, and which are switched with the regular line leads. Since a standard distributing-type terminal assembly is designed for 300 and 400-point selector banks, two assemblies are placed together in order to accommodate the requirement for the 600-point banks. Therefore, all of the advantages of the standard terminal assembly which is used with large selector groups requiring heavy grading are still retained.

Since the primary rotary switches require a 400-point bank (50-point switch $\times$ 8 levels $=$ 400 points), the selector-type distributing terminal assembly was readily adapted to the rotary switch banks. This is probably the first time that this assembly has been used in place of the customary terminal blocks for terminating rotary switch banks. All banks of selectors, dial rear linkfinders, call distribution primary, secondary and TX trunk rotary switches and outgoing secondary rotary switches are designed with silver-inlaid line and net bank contacts to provide a non-microphonic four-wire transmission path.

a) *Shelves and Trunk Boards*

The jumper-type shelf equipped with jacks, used exclusively with the "FW-1" equipment, has the added advantage of greater flexibility as any shelf position can be readily adapted to many different circuits. On these shelves, only the common wires are jumpered from the switch positions to the shelf terminal block; for non-multiple connections, the installer cables directly to the shelf jacks at the individual switch positions. These shelves are designed for single and double width switch bases, and have up to three 24- or 36-point jack assemblies to a position to meet the requirements of circuits having many jack terminations.

Trunk boards are 11′-8″ in height as standard; 9′-0″ frames are also available. Selector boards, using the "twin" distributing-type terminal assembly with associated left and right bays, have an over-all length of 25′-6″: each selector trunk board measures 8′-10½″, and the two terminal assemblies together are 7′-9″. Primary rotary switch boards, with distributing terminal assembly and associated left and right bays, measure 12′-0″, over all; each rotary switch bay

is 3′-9″ wide; the terminal assembly is 4′-6″ wide.

Trunk, position, link, sender control, sender finder, sender, dial rear finder, outgoing secondary rotary switch, alternate routing trunk, and register sender circuits, and some miscellaneous circuits, mount on 5′-11″ trunk boards on smaller installations. On larger jobs the shelves for large trunk circuit groups are longer; the trunk boards for these trunk circuits are 8′-10½″ wide; for the position, link, sender control and sender finder circuits the boards are 8′-0″ wide; and for the dial rear finder circuits they are 9′-1¾″ wide.

For small and for large installations, respectively, 12-switch and 20-switch shelves are used for the trunk and some of the miscellaneous circuits, 12-switch and 16-switch shelves for the position, link, sender control and sender finder switches and 12-switch and 18-switch shelves for the dial rear finders.

b) *Relay Racks*

Circuits that are not jacked-in (such as checking, position and lamp control, TX distributing rotary switch, training rotary switch, position and sender test, busy control relays for O. G. secondary rotary switch and alternate-routing trunks, control console, test, rate-and-route, and Trafficorder circuits) mount on relay racks 2′-0⅜″ wide on a unit-mounting basis; each circuit or group of circuits forms a complete assembly, wired to a self-contained terminal block.

Figure 66. Control Console

c) *Relays and Rotary Switches*

Twin-contact, long-life, dependable Type 57 relays are used throughout the system. The Type 45 rotary switch used in the primary, secondary and TX call distribution, O.G. secondary, sender finder and checking circuits, and the Type 44 rotary switch in the sender circuit, combine high speed, accuracy and durability.

CROSS-CONNECTIONS

Cross-connections are wires loosely run between equipment and circuit terminals, and arranged so that they may be changed or easily removed—such, for example, as the jumper-wire connections at a distributing frame. Normally a great percentage of circuit interconnections on an installation are of this type; this is certainly true of the "FW-1" system, which uses a multitude of cross-connection schemes at the distributing and equipment frames. In addition, there are certain circuits that are interconnected by cable and would therefore, not be classified as cross-connected, which, however, may be of sufficient interest to merit consideration here. Therefore, we are including here any interconnection of circuits that is considered worthy of comment.

Generally, if it is possible, equipment units are directly cabled, and cross-connections are used only when flexibility is to be maintained. Reference to the schematic diagram in Figure 67 shows the many interconnections required between circuits. This drawing shows only the CLR trunk and associated circuit connections. A schematic of practically all of the circuits requiring such connections is shown in Figure 41, already referred to. Grading and cross-connections of the toll selector banks is not discussed, since the conventional selector grading scheme used is generally a familiar subject.

Incoming Call Distribution

The incoming call distribution comprises forward-searching primary and partial-preselecting secondary rotary switches. This distribution may properly be considered basic to the successful operation of the "FW-1" automatic toll switch-

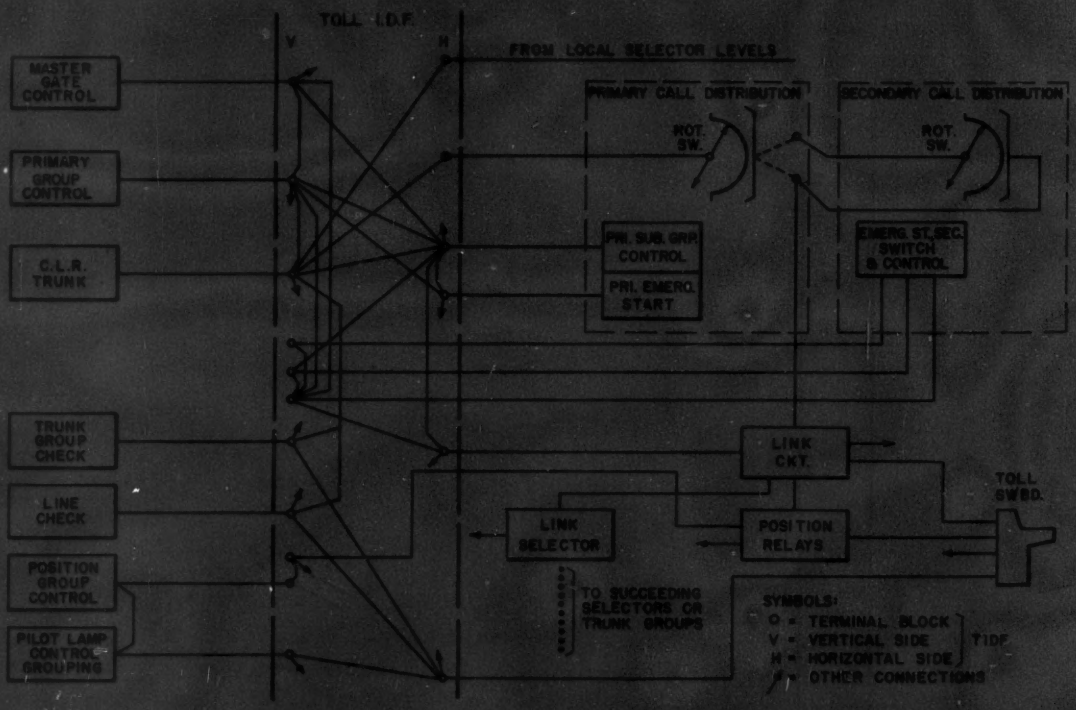


Figure 67. Segment of Cabling and Cross-Connecting Diagram Showing CLR Trunk and Associated Circuits

board. Almost every call directed to the toll board passes through an incoming call distributing system. The call enters the distribution scheme, and must automatically select an idle link to an idle operator. This method of operation is described on Page 104, Technical Journal, December, 1956, issue. The diagram, Figure 69, also shows the relationship of the primary and secondary rotary switches to the circuits preceding and following the distribution, or the particular routing paths that a call must follow in going through the system.

Some of the earlier automatic toll switchboards made by Automatic Electric Company employ a different system of distribution. Instead of the trunk circuit finding an idle link, the idle link is associated with a Strowger link finder switch which finds the incoming trunk that is marked on the finder bank. This system employs 100 and 200-point link finder switch banks and is more suited to smaller installations.

In the following distributing scheme the primary rotary switch banks have direct access to 16-positions, but through secondary switches as many as 48-positions can be reached. Theoretically any call has possible connection to all links of the 48-positions; hence the term "full availability" is used to describe the accessibility of a call to the position links. Limiting each call to a choice of 48-positions is the direct result of using 50-point secondary rotary switches; if 100-point secondaries were used, the number of positions available to a call entering the distribution system would be increased up to the 100 mark. However, the design so far has been with 50-point rotary switches, so that a distribution has a capacity of 48-positions, which is termed a "unit".

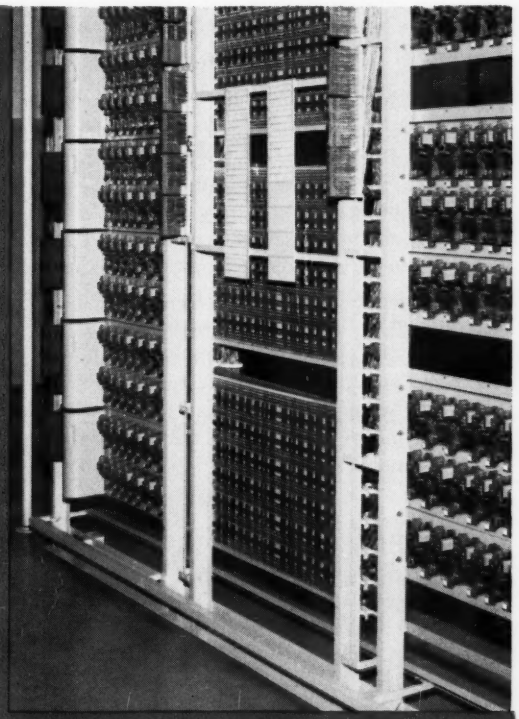


Figure 68. Primary Rotary Switch Shelves of Incoming Call Distribution

Switchboard installations of greater size than 48-positions are built up of a number of such units, each unit being separate and distinct from every other. While it would be possible to provide for the overflow of calls from one unit to another when all of the operators in a unit are busy, the added cross-connection complications that would result hardly justify it; furthermore, the traffic to any unit can be controlled so that few instances of overflow calls would be needed. It is also considered that there would be only a negligible increase in efficiency on an overflow call basis when using fully available position groups as large as 48-positions, since groups this size should practically provide maximum efficiency.

The question of how many primary and secondary switches to use is a problem in traffic calculations, based upon theory and verified by actual tests which are run on the equipment at toll offices. The diagram, Figure 69 shows the incoming call distribution cross-connections from primary rotary switch banks to the link circuits on a direct connection, from primary rotary switch banks to secondary rotary switches, and from the secondary rotary switch banks to the links.

Figures 68, 69 and 70 also show that one primary group consists of seven (plus, usually, one spare) sub-groups for a toll switchboard with seven links in each position. Each sub-group consists of six 50-point rotary switches with fully multipled banks terminated on the distributing-type terminal assembly. A shelf is equipped with 12 rotary switches, and thus comprises two sub-

groups. Four shelves in a bay, therefore, make up a primary group—the lower half of the bottom shelf being wired but not equipped for one sub-group (six rotary switches) or for the spare sub-group. Between sub-groups on a shelf, the banks are reversed through the shelf local cable forms, so that in a primary group, the odd-numbered sub-group banks are reversed with respect to the even-numbered sub-group banks.

Two primary groups are paired with reverse-multiple connections, made at the bank contacts, which have direct link terminations. Each group in a pair is in a separate bay, and these bays are on opposite sides of the common terminal assembly. Direct link reverse-multiple bank connections are made simply by strapping adjacent terminals on the terminal assembly. Together, the paired primary groups have a capacity of 16-positions; therefore, it requires six primary groups to form a 48-position unit. The associated 50-point secondary rotary switches connected to the six primary groups of 48-positions, consist of seven (and one spare) 24-switch shelves. Forty-eight contacts of the 50-point secondary switches are connected to the 48-positions of the associated primary groups.

Each sub-group connects to the same-numbered links in 16-positions, from the banks that run direct to the link circuits. Thus, of two primary paired groups associated with the 16-positions, the two sub-groups (1) will connect in reverse-multiple to the 1 links of the 16-positions, the two sub-groups (2) will connect in reverse multiple to the 2 links and so on for the full number of seven sub-groups. The positions are connected to the banks in numerical sequence, of which the following is typical for the first 16-positions. Since the primary rotary switches are forward-searching, it is not necessary to arrange the positions in any other order of connection to the rotary switch banks.

Primary Group 1 Sub-Group 1 to 7 Bank Contacts (not multipled)	Switchboard Position Number
1	1
4	2
7	3
10	4
13	5
16	6
19	7
23	8
28	9
32	10
35	11
38	12
41	13
44	14
47	15
50	16

Since the odd-numbered and the even-numbered sub-group banks in a primary group are distributed in reverse, the odd-numbered sub-groups will hunt positions 1 to 16, while the even numbered sub-groups will hunt positions 16 to 1, in that order. Spreading the direct-link bank contacts from 1 to 50 instead of taking the first 16 contacts will avoid placing the 32 secondaries on contacts 17 through 48. Since all of the secondaries will test busy as long as direct links are available, the wipers would have to step over busy contacts 17 to 48 with each revolution before gaining access to a direct link. This is the reason for interposing the secondary contacts with the direct link contacts.

All secondary contacts in the primary group are multipled. From each primary group there are seven sets of four trunks, each going to secondary rotary switches and each set going to a different secondary group. With six primary groups associated with 48-positions, there will be a total of 24 secondary rotary switches in each of seven secondary groups. The primary bank distribution of the secondary contacts is arranged to provide for potential pre-selection of all of the secondary groups by only one-quarter revolution of the rotary switch, and thus avoids congested secondary groups; the following arrangement of one primary group is typical:

Primary Group 1 Sub-Group 1 to 7 Bank Contacts (multipled)	Secondary Rotary Switch Shelves	
	Switch Pos.	Group
2	1	1
3	1	2
5	1	3
6	1	4
8	1	5

9	1	6
11	1	7
12	Fut.	Fut.
14	2	1
15	2	2
17	2	3
18	2	4
20	2	5
21	2	6
24	2	7
25	Fut.	Fut.
26	3	1
27	3	2
30	3	3
31	3	4
33	3	5
34	3	6
36	3	7
37	Fut.	Fut.
39	4	1
40	4	2
42	4	3
43	4	4
45	4	5
46	4	6
48	4	7
49	Fut.	Fut.

Each secondary group is associated with all of the same-numbered links in 48-positions—secondary group (1) with links 1, secondary group (2) with links 2, and so on, for the full number of seven groups. In order to provide a "scrambled" effect between secondary groups, however, the bank contacts in each of the secondary groups are to have as completely different and divergent a pattern of position connections as it is possible to obtain. Since the secondary rotary switches are pre-selecting, the intention is to minimize the number of secondaries simultaneously hunting for a free link.

Trunk-Checking Circuit

Figure 71 shows the wiring required for the trunk-checking circuit. The interconnections between circuits can be made at the toll intermediate distributing frame. When an operator throws the front or rear check key, the checking circuit becomes associated with the position indicated by the lighting of the position pilot lamp, and until the check key is released, no other operator may seize the checking circuit. In checking a trunk, the trunk group, "tens" and "units" lamps light in multiple in 12 switchboard sections (24-positions). The capacity of the trunk-checking circuit, using 24-position multiples, is 600-positions; on small switchboards fewer positions can be multipled together in the checking circuit, since only a small fraction of the capacity of the checking circuit would otherwise be used.

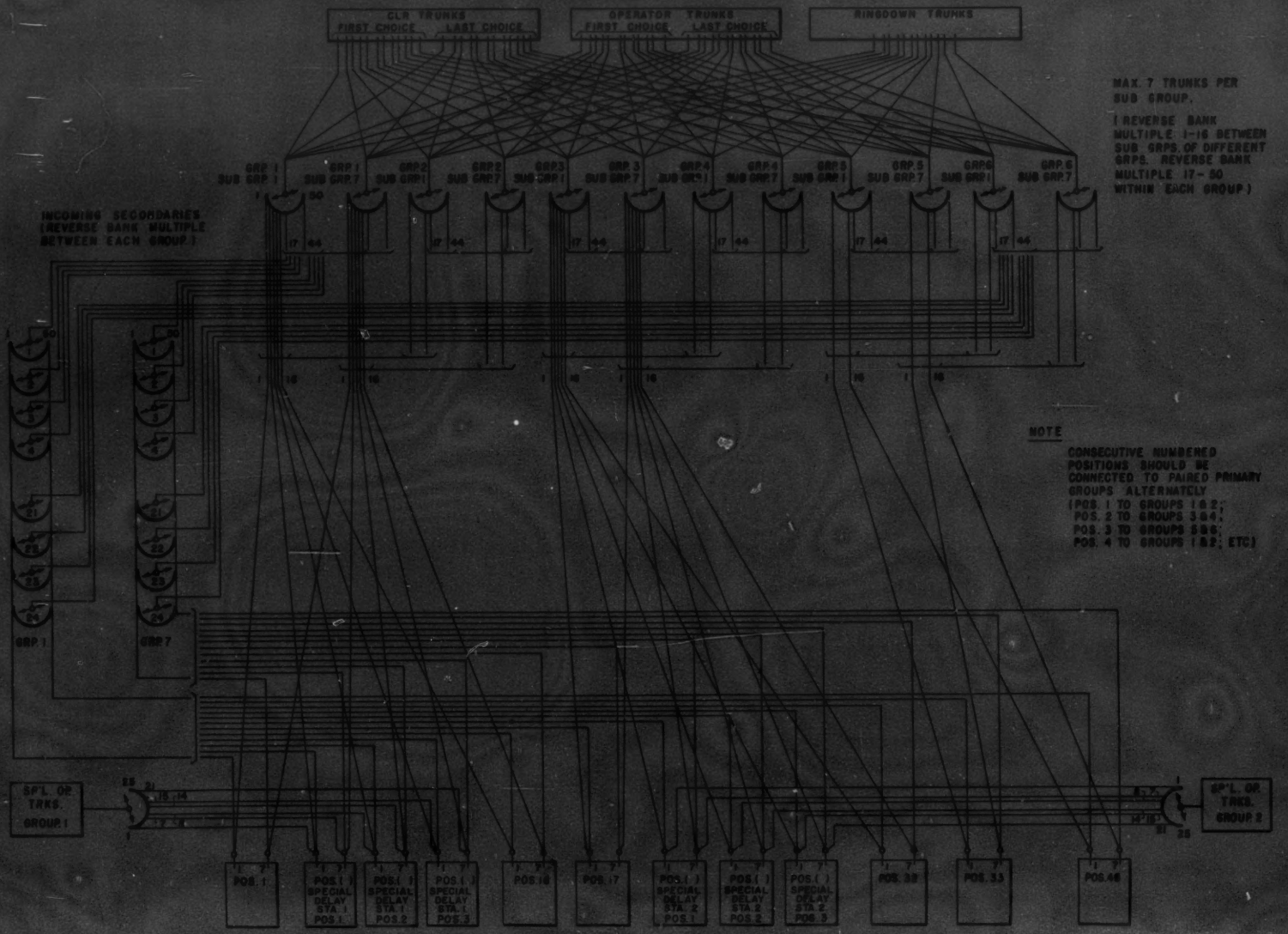
Position Lamp Control Distribution

Figure 72 shows the distribution of wiring between the switchboard group busy lamps and the position lamp control relay circuit. Similar wiring is used for the switchboard answer pilot, sender busy, posted delay, position and sender test lamps with the position lamp control circuit, and the position and sender test relay circuit. This method distributes the lamps so that not more than 12 lamps (serving 24-positions) operate in multiple from the lamp control grouping circuit, and also keeps the lamps from lighting in any 24-position group if there are no positions staffed in that group.

Position Link-To-Link Selector Connections

Connections between position links and associated link selectors may be made at the distributing frame, with jumpers or by direct cabling. When the number of link selectors is not large enough to justify mounting the link, intertoll and dial rear selectors on separate trunk boards, the cabling of all selectors to the I D F probably offers the greater flexibility. Then the links would also be cabled to the I D F for cross-connection to the link selectors. However, on very large installations where there are many link, intertoll and dial rear selectors, separate trunk board mountings are made, providing for the combined intertoll and dial rear selectors in one group and the link selectors in another group. In this case, the link selectors are cabled directly to link circuits; the intention is, of course, to combine these selectors in the most efficient, yet practical grading scheme, keeping in mind also the minimization of transmission losses.

Whichever scheme is used for connecting the position links to link selectors, each of the links from any one position is distributed to a selector


CLR TRUNKS
FIRST CHOICE LAST CHOICE
OPERATOR TRUNKS
FIRST CHOICE LAST CHOICE
RINGDOWN TRUNKS
MAX. 7 TRUNKS PER SUB GROUP.
I REVERSE BANK MULTIPLE I-16 BETWEEN SUB GRPS. OF DIFFERENT GRPS. REVERSE BANK MULTIPLE 17-50 WITHIN EACH GROUP.)
GRP 1 SUB GRP 1
GRP 1 SUB GRP 7
GRP 2 SUB GRP 1
GRP 2 SUB GRP 7
GRP 3 SUB GRP 1
GRP 3 SUB GRP 7
GRP 4 SUB GRP 1
GRP 4 SUB GRP 7
GRP 5 SUB GRP 1
GRP 5 SUB GRP 7
GRP 6 SUB GRP 1
GRP 6 SUB GRP 7
INCOMING SECONDARIES (REVERSE BANK MULTIPLE BETWEEN EACH GROUP.)
GRP 1
GRP 7
SPL. OP. TRKS. GROUP 1
SPL. OP. TRKS. GROUP 2
POS. 1
POS. 2 SPECIAL DELAY STA. 1 POS. 1
POS. 3 SPECIAL DELAY STA. 1 POS. 2
POS. 4 SPECIAL DELAY STA. 1 POS. 3
POS. 16
POS. 17
POS. 18 SPECIAL DELAY STA. 2 POS. 1
POS. 19 SPECIAL DELAY STA. 2 POS. 2
POS. 20 SPECIAL DELAY STA. 2 POS. 3
POS. 32
POS. 33
POS. 46

NOTE

CONSECUTIVE NUMBERED POSITIONS SHOULD BE CONNECTED TO PAIRED PRIMARY GROUPS ALTERNATELY (POS. 1 TO GROUPS 1 & 2; POS. 2 TO GROUPS 3 & 4; POS. 3 TO GROUPS 5 & 6; POS. 4 TO GROUPS 1 & 2; ETC.)

Page 24 Incoming Call Distribution

on a different shelf. This will scatter the traffic evenly over all shelves; also, in case any selector shelf should become disabled, only one link in any position would be affected.

Primary Rotary Switch Assignments

As previously mentioned, six primary rotary switch groups comprise a 48-position unit with each two primary groups in the unit being paired to connect to 16 of the positions. In each of these six primary groups there are seven sub-groups, with six rotary switches in each—therefore in the 48-position unit there is a total of 252 primary switches. In order to provide an equitable division of the CLR and operator trunk circuit traffic to these rotary switches, it is necessary to distribute first-choice, second-choice, third-choice, etc., trunks evenly over the various sub-groups, as illustrated in the incoming call distribution diagram, Figure 66. Ring-down trunks are likewise proportionately scattered over the sub-groups, in order also to distribute this traffic.

Dial-Rear Finder Bank Assignments

The Strowger dial-rear finder associates itself with the position link on which the dial-rear key is operated. Permanently connected to this finder is the dial-rear selector, so that once the finder seizes a link, pulsing may be started over the link and through the dial-rear selector.

There are 18 dial-rear finders in each finder group, and the shelf of 18 finders is equipped with 600-point, 10-level banks. Each level is assigned to all of the links of a position, so that each shelf or finder group can be associated with 10 toll positions. Besides the regular bank terminal blocks, the shelf is also equipped with cross-connecting terminal blocks, to which the position links are directly cabled. The connections to the bank blocks are, therefore, made by jumpers—there being no permanent cabling of link to dial-rear finder bank levels. In this way each dial-rear finder bay is given its own cross-connection facilities, so it is an easy matter to reassign the links of any position to another finder group whenever a redistribution of traffic becomes necessary. With six finder shelves in a bay, flexible cross-connection facilities are thus made available for the up to sixty toll positions that can be connected in the bay.

EXCHANGE CABLING

Because the cabling required is very extensive, careful planning is done beforehand so that the most efficient and economical routing of cables, and interconnection of equipment units, can be effected. In many cases a circuit has quite a few common connections with several different circuits but requires changes from time to time and it is therefore, most desirable to make such circut connections at an intermediate distributing frame. Whenever possible, cables are run direct between circuits: it is necessary, however, to be fairly certain, in such cases, that there will be no changes in the future, and that the flexibility which the intermediate distributing frame provides is not being sacrificed. On large installations, several I D F's are used in order to decentralize cabling with respect to the floor plan layout, so that cable runs can be kept at minimum length.

The line and net conductors comprising each four-wire circuit require quad cabling. Since the connections between two points include quadded, paired and single wires, special cables have been designed, combining these wires within one sheath.

MAINTENANCE

For efficient maintenance, the equipment is designed for quick identification and tracing of calls, and for making routine and emergency tests through test jacks and toggle switches mounted on the switches, shelves and trunk boards.

CONCLUSION

Many more physical features and cross-connections could be described, but it is hoped that the preceding description of its representative features considered has given you some idea of the practical engineering problems involved in the "FW-1" Intertoll Switching System and Automatic Toll Switchboard. The system is truly ultra-modern, and is keeping pace with contemporary advancements in this pushbutton age. It should be interesting to the telephone engineer and layman to watch this system develop in the future.

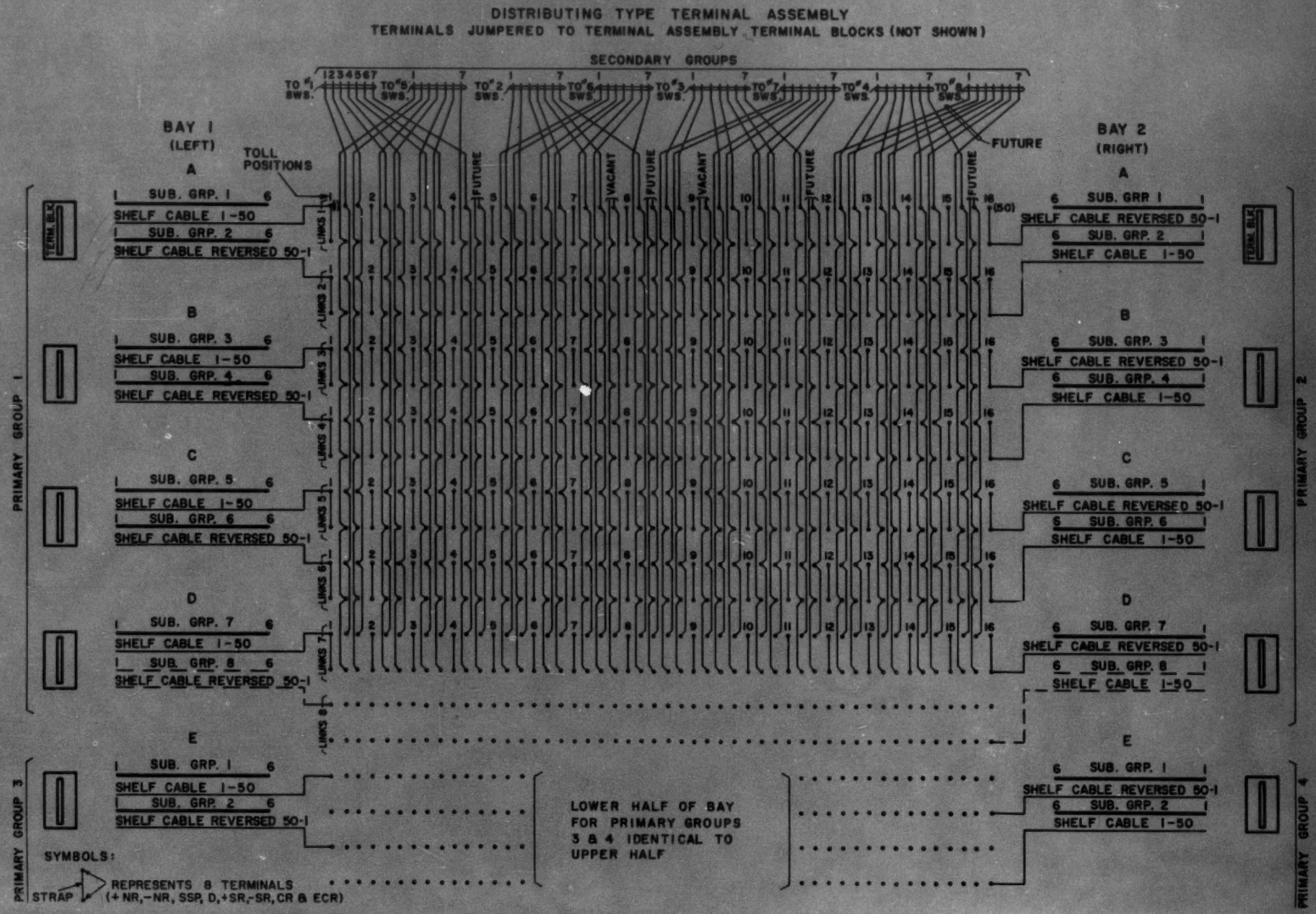


Figure 70. Incoming Call Distribution Primary Rotary Switch Bays and Distributing Type Terminal Assembly

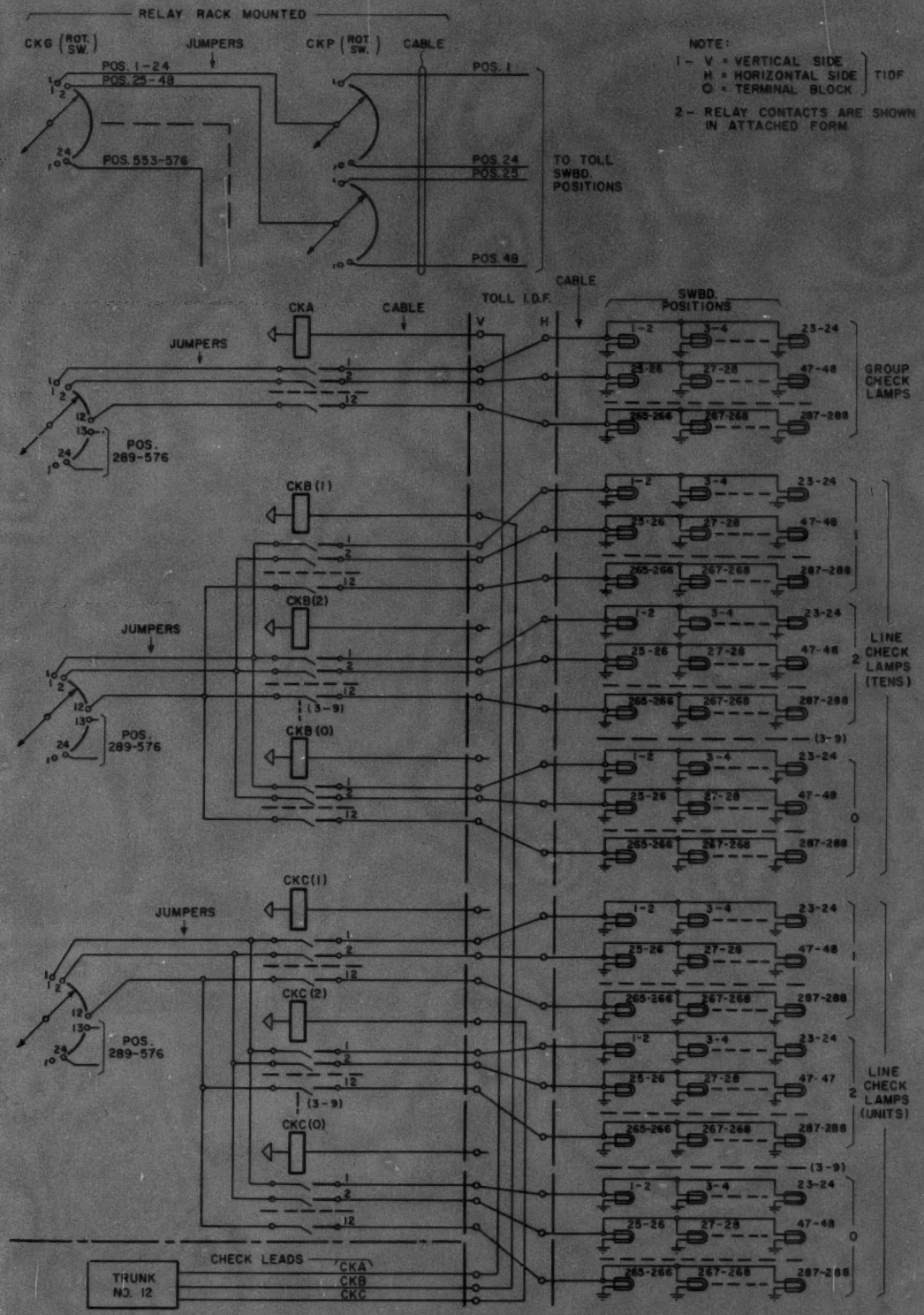
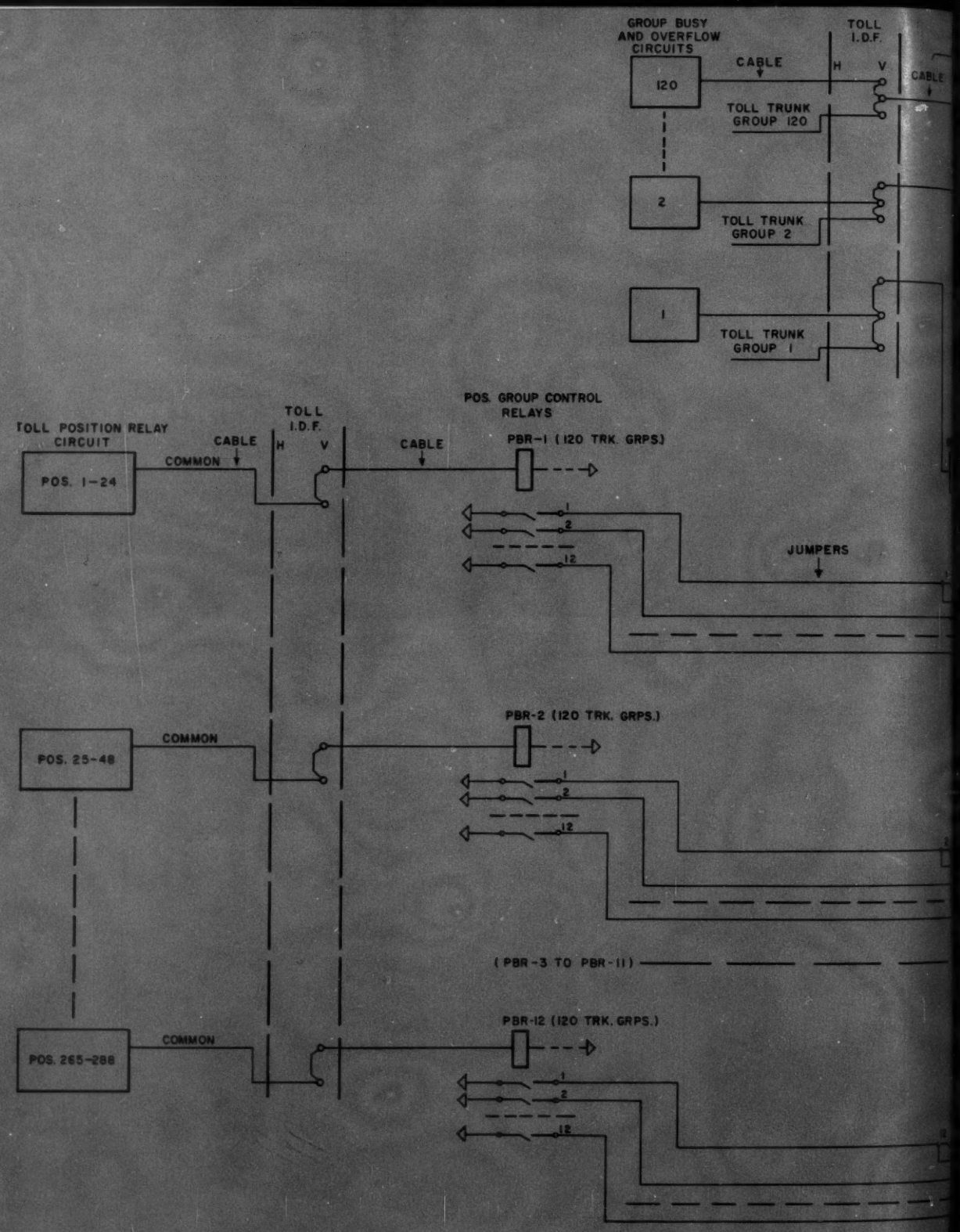


Figure 71. Schematic Diagram of Trunk Checking Circuit Connections


GROUP BUSY AND OVERFLOW CIRCUITS
TOLL I.D.F.
CABLE
H
V
CABLE
120
TOLL TRUNK GROUP 120
2
TOLL TRUNK GROUP 2
1
TOLL TRUNK GROUP 1
POS. GROUP CONTROL RELAYS
TOLL POSITION RELAY CIRCUIT
CABLE
TOLL I.D.F.
H
V
CABLE
PBR-1 (120 TRK. GRPS)
POS. 1-24
COMMON
1
2
12
JUMPERS
PBR-2 (120 TRK. GRPS.)
POS. 25-48
COMMON
1
2
12
(PBR-3 TO PBR-11)
PBR-12 (120 TRK. GRPS.)
POS. 265-288
COMMON
1
2
12

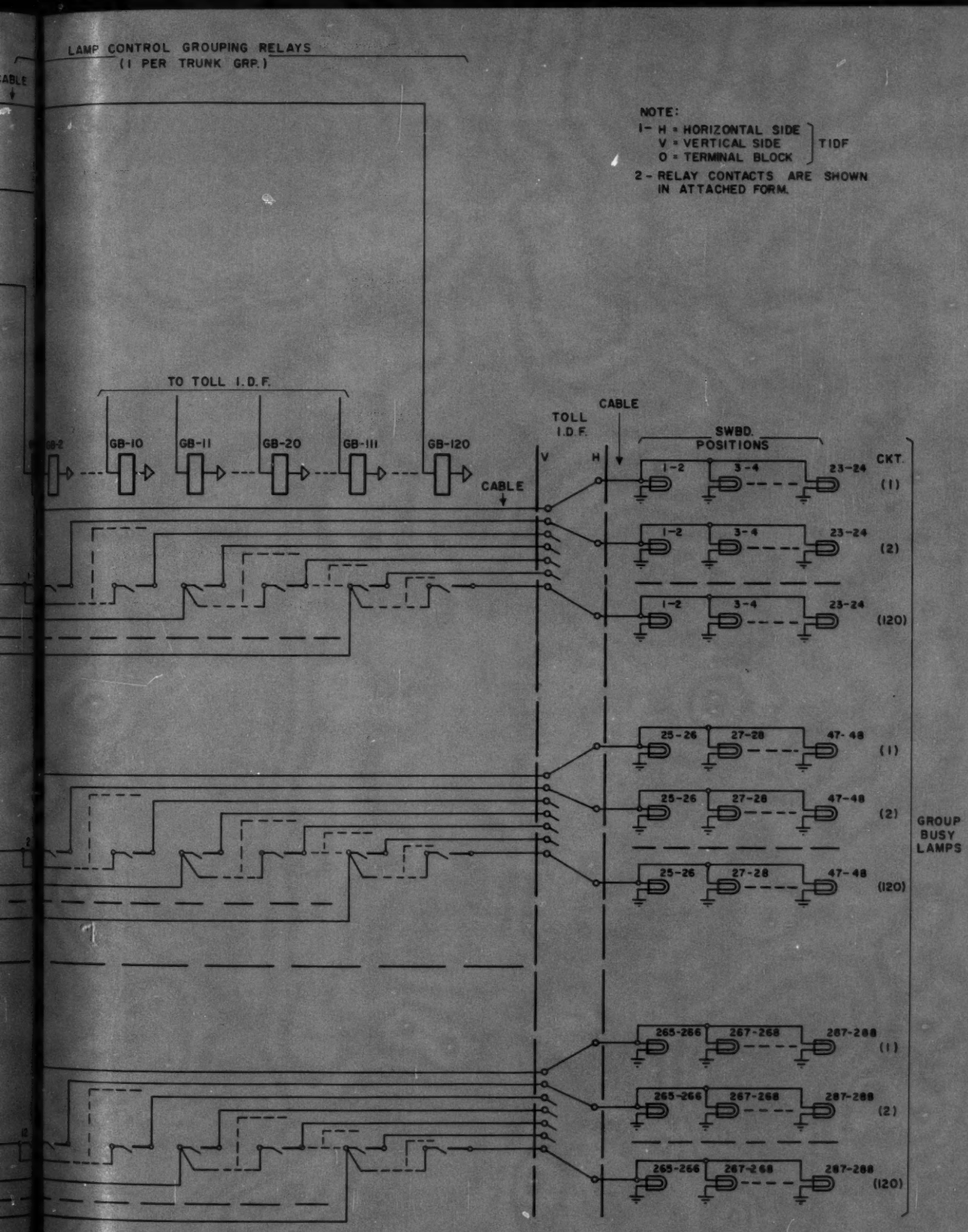


Figure 72. Schematic Diagram of Position Lamp Control Distribution for Group Busy Lamps

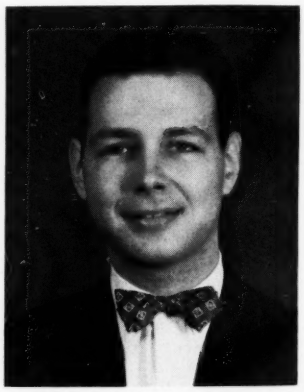
Introducing the Engineers who

ROBERT T. EVANS

Graduated from the University of Wisconsin in 1950, with the degree of B. S. in Electrical Engineering. He started with Automatic Electric as a student in the training program. After assignment to Technical Publications and Quality Control, he was an instructor in the Training School. After a leave of absence for military service he returned to the company in 1953, and was assigned to the Testing Bureau. Mr. Evans is at the present time working on toll systems as a Staff Engineer in the Telephone Switching Systems Development Section of the Laboratories. He is a member of the American Institute of Electrical Engineers.

EDWARD J. GLENNER

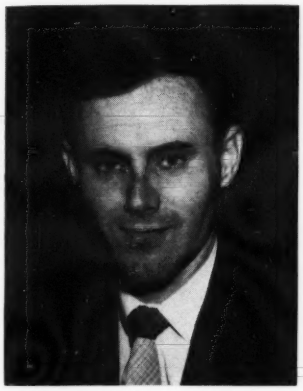
Graduated from Northwestern University with the degree of B.S. in Electrical Engineering in 1948. He started at Automatic Electric in the Training School, then was assigned to Systems Engineering and the Testing Bureau. In 1950, he taught two classes in circuit operation in the Training School. Mr. Glenner has been engaged in toll systems development and is now working on toll ticketing as a Project Engineer in the Telephone Switching Systems Development Section of the Laboratories. Mr. Glenner is a member of the American Institute of Electrical Engineers, and of Eta Kappa Nu, the Electrical Engineering honorary fraternity.



J. D. LOGAN

J. D. Logan received the degree of Bachelor of Applied Science in mechanical engineering from the University of British Columbia in 1942. Following graduation, he was engaged in the production and testing of shock-proof circuit breakers for the British Admiralty. In 1946 he entered the Traffic Engineering Department of the British Columbia Telephone Company, working on automatic engineering projects. During 1953 he prepared the traffic recommendation for the first FW-I automatic toll switching system recently installed at New Westminster, B. C. Early in 1956 Mr. Logan was appointed to the position of toll line traffic engineer.

...note these articles...



G. F. MacFARLANE

G. F. MacFarlane attended the University of British Columbia from 1946 to 1950, graduating with a Bachelor of Applied Science degree, honors standing, in electrical engineering. He joined the British Columbia Telephone Company on graduation and spent the winter of 1951-52 in Chicago with Automatic Electric working on dial conversion plans for North Vancouver. In 1955 he was appointed to the position of automatic equipment engineer. He is a member of the Engineering Institute of Canada, the American Institute of Electrical Engineers, and the British Columbia Association of Professional Engineers.

S. G. PATTERSON

S. G. Patterson graduated from the University of British Columbia with the degree of Bachelor of Applied Science in electrical engineering. Until the end of the war he served with the Canadian Army in radar installation and maintenance. At that time he entered the service of the Government Telegraph and Telephone Service as communications engineer. In 1948 he joined the British Columbia Telephone Company and remained with the toll and manual equipment engineering section until April, 1955, when he transferred to the Plant Extension Department as construction program and cost studies engineer.

FRANK A. GHISELLI

Graduated from the University of Illinois with the degree of B. S. in Electrical Engineering in 1937. He started work with Automatic Electric in the Training School the same year. Later he was assigned to the Laboratories. Succeeding positions were in the Engineering Department as an Automatic Equipment Engineer, Sales Department in Washington, D. C. as Sales Engineer, and the Operating Department as Staff Engineer. He is now a member of the Engineering Department as a Manual Equipment Engineer. Mr. Ghiselli is a member of Eta Kappa Nu, the Electrical Engineering honorary fraternity.